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POTENTIAL MUNICIPAL AND INDUSTRIAL WATER QUALITY REQUIREMENTS, AND QUANTITY AND QUALITY OF RETURN FLOWS IN THE NECHES, TRINITY, COLORADO, SAN JACINTO, BRAZOS, SAN ANTONIO, GUADALUPE, AND NUECES RIVER BASIN AND ADJOINING AREAS

Public Health Service
Washington, D. C.

May 1960

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AND

QUANTITY AND QUALITY OF RETURN FLOWS

IN

THE NECHES, TRINITY, COLORADO, SAN JACINTO, BRAZOS, SAN ANTONIO, GUADALUPE, AND NUECES RIVER BASINS AND ADJOINING AREAS

Prepared for the

U. S. STUDY COMMISSION - TEXAS
Houston, Texas

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

in collaboration with the

Bureau of Reclamation
Texas Department of Health
and the
Texas Board of Water Engineers

MAY 1960

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INTRODUCTION AND SCOPE

This report has been prepared in accordance with Work Plan Outline Cla, "Municipal-Industrial Water Requirements", attached to the Memorandum of Understanding Between the U. S. Public Health Service and the U. S. Study Commission - Texas, dated 9 November 1959. The report is intended for inclusion as a supplement to the Bureau of Reclamation's interim report on preliminary annual water requirements as described in Alc of the Work Plan.

Quality of water is measured in terms of the amount of specific impurities it may contain. Although there is a myriad of water-soluble materials, only those impurities that are specifically detrimental to a subject user will be discussed in the quality requirements section. That section includes statements on the quality requirements of municipal use, nine major categories of industrial use, irrigation, stock watering, and recreation.

To be readily correlated with the Bureau of Reclamation's interim report, the quantities of return flows in each substudy area are stated in terms of million gallons per year for the years 1975 and 2010.

The corresponding quality of these return flows is expressed in terms of three quality-related constituents: biochemical oxygen demand, minerals, and organics; these are each expressed in terms of tons per year. By noting the relative amounts of these constituents in the return flows from each subarea, potential problem areas may be anticipated in the years 1975 and 2010.

No attempt has been made to predict the quality changes in the receiving waters that the above return flow constituents may produce. This has been left to second-stage planning for three reasons: (1) the concentration of these constituents in the receiving waters will depend on the altered regimen and flows of the second stage of optimum development; (2) the constituents tabulated in this report are incremental to the constituents already in the water as received by the municipality or industry. Thus, a cumulative concentration will develop, especially of minerals, as the water progresses downstream, from one user to the next; and (3) irrigation water requirements have not been considered in the interim report. Until the return flows from irrigation use are accounted for, receiving water quality cannot be realistically evaluated.

At the time this report was prepared, firm estimates of water requirements in the Neches and Trinity River Basins had not been established for the years 1975 and 2010. Upon receipt of accepted water requirements, the Public Health Service will prepare estimates of the quantity and quality of corresponding return flows for these basins.

SUMMARY

Water Quality

Water quality is measured in terms of the amount of impurities that it contains. These impurities may be classed according to their chemical, physical, or bacterial properties. There is no single standard for limiting the concentrations of these impurities; water quality requirements to meet the needs of municipalities are established (with periodic revisions), but the requirements of industry vary widely.

Water quality at any point in a stream may be altered by return flows of upstream users. Three primary categories of waste products are minerals, organics, and that portion of the organics that is nutrient for biological organisms. The latter organic matter may be expressed in units of "biochemical oxygen demand" and represents materials that are amenable to natural stabilization. The remaining portion of organics may include compounds that are relatively immune to normal biochemical stabilization and may even be toxic to some living organisms; these include insecticides, herbicides, synthetic detergents, and an increasing number of other exotic organic chemicals.

Quantity and Quality of Return Flows

Seven of the nine USSC-T areas have been evaluated in terms of return flows and their incremental waste constituents. Table S-1 shows the annual amount of return flow and tons of biochemical oxygen demand, minerals, and organics that may be anticipated in each of these study areas. Figure S-1 portrays graphically the mineral and return flow-portions of Table S-1 to aid in arraying the data.

The per cent of these total loadings (based on constituent minerals) that may be anticipated in each of the subareas is indicated in Table S-2. By use of these tables, the relative importance of potential future problem areas may be identified. As an example, Table S-1 shows that the greatest amount of materials added by return flows in 1975 will be in the Brazos River Basin; Table S-2 shows that 19, 18 and 17 per cent of these minerals will originate in subareas 4B, 4A and 1B of the Brazos River Basin, respectively. Reference to the map of the Brazos River will show the location of these potential quality-problem areas, and the amounts of each constituent that may be expected in the return flows are in Table B-2. The river reach, square miles drained, projected population and population density for each of these subareas is tabulated in Table B-1.

Each of the Commission study areas has been evaluated by the above procedure in preparation for a more detailed monthly evaluation during second stage planning. The real significance of the return flows with their incremental constituent loads will not be known until they are correlated with anticipated flows in their receiving streams.

FIGURE S-1

POTENTIAL RETURN FLOWS & MINERALS ADDED IN 1975 & 2010
USSC-T AREA

(Return Flows in Million Gallons per Year -- Minerals in Tons per Year)

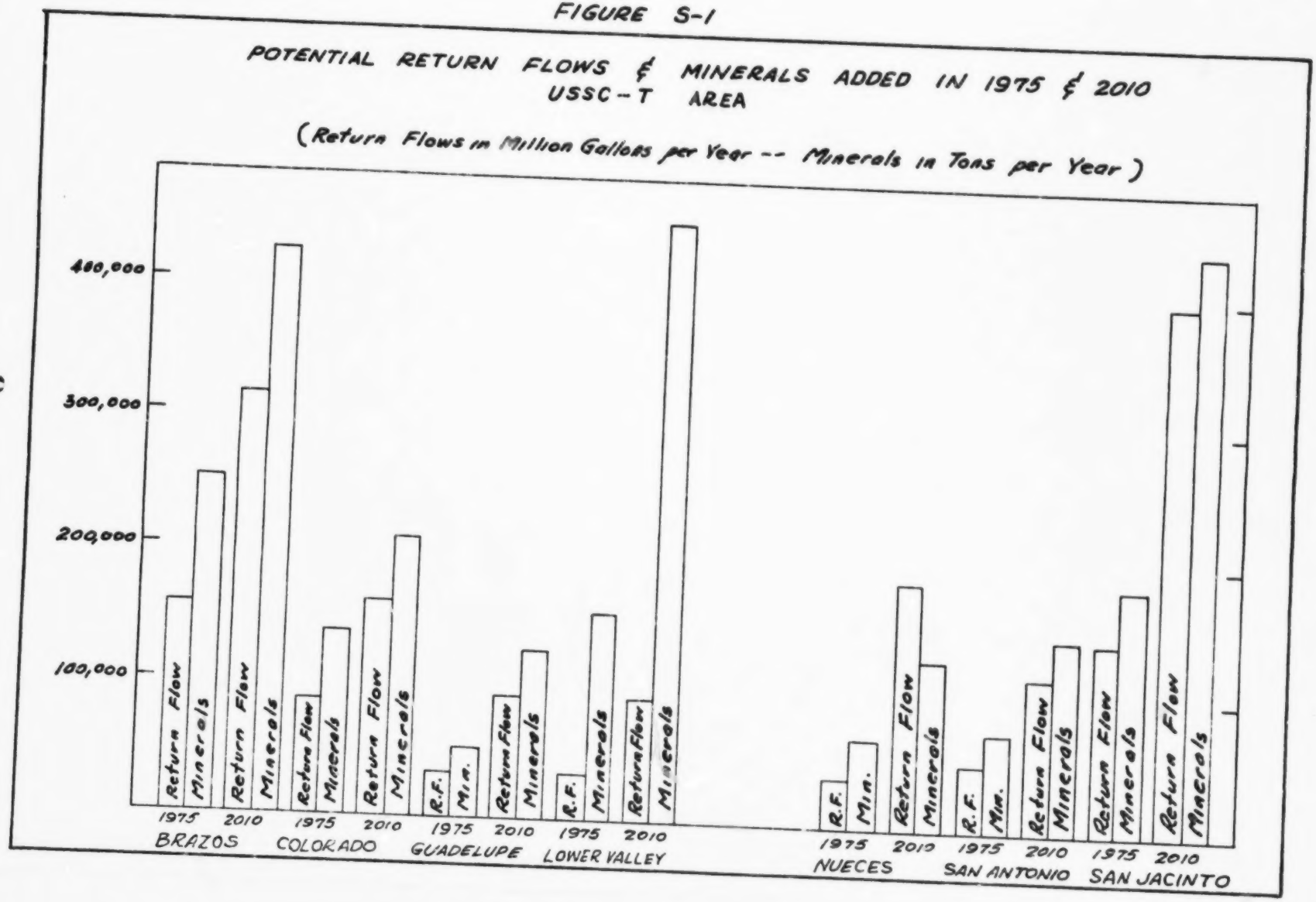

Table S-1

RETURN FLOWS AND WASTE CONSTITUENTS ADDED AFTER TREATMENT
BY MUNICIPAL AND INDUSTRIAL USERS
1975 and 2010

Basin	1975 Return Flow MGY	1975 Constituents Added by Users BOD Tons/yr	1975 Minerals Tons/yr	1975 Organics Tons/yr	2010 Return Flow MGY	2010 Constituents Added by Users BOD Tons/yr	2010 Minerals Tons/yr	2010 Organics Tons/yr
Brazos, Total	156,910	20,410	250,170	26,250	314,550	40,130	421,490	49,220
Industrial	87,300	10,510	172,750	13,570	182,160	25,110	304,010	30,100
Nonindustrial	69,610	9,900	77,420	12,680	132,390	15,020	117,480	19,220
Colorado, Total	87,520	12,230	137,810	15,800	160,280	21,980	206,350	28,280
Industrial	48,310	6,780	95,430	8,850	98,170	14,300	146,300	18,430
Nonindustrial	39,210	5,450	42,380	6,950	62,110	7,680	60,050	9,850
Guadalupe, Total	31,970	5,170	50,970	6,640	91,020	12,320	124,990	17,520
Industrial	21,150	3,020	34,160	3,890	67,100	8,360	93,990	12,450
Nonindustrial	10,820	2,150	16,810	2,750	23,920	3,960	31,000	5,070
Lower Rio Grande Valley Total	33,570	5,830	153,140	7,500	89,920	13,700	445,990	17,640
Industrial	22,630	3,280	133,180	4,230	67,560	9,790	415,380	12,630
Nonindustrial	10,940	2,550	19,960	3,270	22,360	3,910	30,610	5,010
Neches, Total								
Industrial								
Nonindustrial								
Nueces, Total	36,430	5,840	64,480	7,470	185,570	11,450	128,390	14,690
Industrial	20,490	2,010	34,390	2,540	69,530	4,280	72,280	5,520
Nonindustrial	15,940	3,830	30,090	4,930	116,040	7,170	56,110	9,170

Table S-1 (Continued)

Basin	1975 Return Flow MGY	1975 Constituents Added by Users BOD Tons/yr	1975 Minerals Tons/yr	1975 Organics Tons/yr	2010 Return Flow MGY	2010 Constituents Added by Users BOD Tons/yr	2010 Minerals Tons/yr	2010 Organics Tons/yr
San Antonio, Total	49,060	6,000	72,280	7,700	116,050	12,000	145,330	15,380
Industrial	9,830	1,270	35,370	1,640	19,860	2,560	71,490	3,290
Nonindustrial	39,230	4,730	36,910	6,060	96,190	9,440	73,840	12,090
San Jacinto, Total	143,620	19,610	182,590	25,200	396,590	51,410	433,910	66,190
Industrial	95,950	12,620	128,020	16,280	279,260	36,830	319,900	47,530
Nonindustrial	47,670	6,990	54,570	8,920	117,330	14,580	114,010	18,660
Trinity, Total								
Industrial								
Nonindustrial								

Assumed treatment: 90% reduction of B.O.D. (Biochemical oxygen demand) and organic matter in municipal wastes and an equivalent quality in industrial return flows.
15% reduction of mineral matter.

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TABLE S-2

Percentage of Minerals Anticipated in Municipal And Industrial Return Flows From Each Substudy Area

Basin	Area	Per Cent Minerals From Each Area 1975	2010	Basin	Area	Per Cent Minerals From Each Area 1975	2010
Brazos	1-A	4	2	Guadalupe	1	1	1
	1-B	17	15		2	<1	<1
	2-A	10	6		3	10	7
	2-B	2	2		4	20	13
	2-C	5	4		5	1	1
	2-D	2	1		6	27	29
	2-E	<1	1		7	15	19
	2-F	1	1		8	16	25
	3-A	1	<1		9	3	1
	3-B	1	<1		10	4	2
	3-C	1	1		11	<1	<1
	3-D	8	6		12	3	2
	3-E	1	<1		Total	100	100
	3-F	1	1				
	3-G	8	9				
	3-H	1	<1				
	4-A	18	16				
	4-B	19	35				
	Total	100	100				
Colorado	1-A	15	11	Lower Rio	1	2	<1
	1-B	19	19	Grande	2	92	95
	2-A	2	2	Valley	3	6	5
	2-B	13	16		Total	100	100
	2-C	4	4				
	2-D	2	1				
	2-E	1	1				
	2-F	1	1				
	3-A	<1	<1				
	3-B	1	<1				
	3-C	<1	<1				
	3-D	13	17				
	4	29	28				
	Total	100	100				

TABLE S-2 (Cont'd)

Percentage of Minerals Anticipated in Municipal
And Industrial Return Flows From Each Substudy Area

Basin	Area	Per Cent Minerals From Each Area	
		1975	2010
Nueces	1-A	<1	<1
	1-B	3	2
	1-C	4	4
	1-D	5	2
	1-E	2	1
	1-F	2	1
	2-A	2	1
	2-B	3	4
	2-C	79	85
	Total	100	100
San Antonio	1	<1	<1
	2	98	98
	3	1	1
	4	1	1
	Total	100	100
San Jacinto	1	<1	<1
	2	1	<1
	3	75	85
	4	24	15
	Total	100	100

WATER QUALITY REQUIREMENTS FOR MUNICIPAL AND INDUSTRIAL USE

Water Quality Defined

There are three basic "yardsticks" for measuring the quality of water. One is based on the chemical content, the second is based on physical properties, and the third is based on the bacteria content of the water.

Any chemical that can be dissolved in water will affect the quality of that water. The long list of these chemicals, from acids to zinc, precludes an item-by-item dissertation on the quality effects of each chemical. Fortunately, the chemicals can be classified into two broad categories, namely inorganic (earthy or mineral) and organic (compounds of carbon); common characteristics of groups of chemicals within these two categories permit further simplification, so that only three chemical classifications will be used in this report to describe the quality aspects of waters in the Basins of the Commission area.

(1) Biochemical oxygen demand

Growth of biological organisms in a water is proportional to the amount of nutrient organic matter available, provided substances which inhibit growths are not present. Growth of these organisms results in a corresponding depletion of dissolved oxygen; thus, by measuring this oxygen depletion, a unit of quality for a major portion of the organic ingredients of the water is established.

(2) Minerals

Minerals include all inorganic chemicals that occur naturally in the mineral kingdom (as distinguished from either the animal or vegetable kingdoms).

(3) Organic material

This category includes all organic compounds, including those in the biochemical oxygen demand category. Specific organic compounds in this group may include detergents, insecticides, herbicides, pesticides, and other organics that not only are immune to normal biochemical stabilization in a stream, but may even be toxic to living organisms; they may contribute to taste, color, or odor, interfere in water treatment or have undetermined physiological affects. The significance of these compounds is discussed under the heading "Organic Chemical Exotics."

Physical quality of a water refers to the readily identifiable properties that include temperature, turbidity, color, solids, taste, and odor.

Bacterial quality is perhaps the most health-significant property of water. Bacteria are invisible to the naked eye, and a sparkling clear water, having good physical and chemical qualities, may contain a lethal number of pathogenic organisms Their presence in a stream that is used for municipal water supplies, recreation, or irrigation is a threat to the health of all persons engaged in these uses or the products thereof. Since bacteria are amenable to a high degree of removal by modern sewage treatment processes, and since the Texas State Department of Health maintains rigid standards for such treatment, municipal return water in the area of concern to the U. S. Study Commission - Texas will be assumed to be of satisfactory bacterial quality.

Certain aspects of water quality are not amenable to numerical tabulation, and others are not amenable to treatment by conventional processes. A brief discussion of these aspects follows:

1. Infectious agents are disease-causing organisms such as the typhoid bacillus and viruses. These are not readily identified and counted in the laboratory; therefore, a sewage-indicator organism (coliform bacteria), that is readily identified and counted, is used routinely in water treatment plants and sanitary surveys of streams to evaluate bacterial quality. Chlorination of effluents from water and waste water treatment plants, when applied in sufficient dosages to reduce the coliform bacteria to insignificant densities, may be expected to effect similar reductions of most pathogenic organisms.

2. Plant nutrients are mineral substances in solution which are used as food by aquatic plant life, such as algae and water weeds normally found in streams and lakes. The two principal nutrient elements are nitrogen and phosphorus. They enter the receiving waters from municipal sewage, some industrial wastes, and runoff from chemically fertilized agricultural lands. Except by the costly process of desalination, these nutrient minerals cannot be removed by conventional treatment methods. Acting as fertilizers in the receiving stream, they stimulate "blooms" of water plants and an unstable aquatic environment. The ensuing death and decay of these organisms create a secondary oxygen demand and intensify taste and odors at downstream water treatment plants. Other detrimental effects of the nutrients include an unnatural green pea-soup appearance of streams, the death of fish, strong odors from dead plants on the shorelines, and interference with boating, water skiing, and swimming; the death and decay of certain types of algae generates a poison resembling strychnine, which has been known to kill ducks, sheep, dogs and cattle that have consumed them while drinking water. Growth of algae in a controlled environment, as in stabilization ponds, is currently practiced in Texas, in areas where the cost of land is not prohibitive. When current research produces a feasible method for harvesting these algae, the plant nutrients will be removed via the algae cells.

3. Organic chemical exotics include detergents and the new insecticides, pesticides, and weed killers. Other persistent substances are discharged with some industrial wastes. None of these exotics is removed from water to a satisfactory extent either by sewage treatment plants or water purification plants. Being relatively new, their effects upon human beings, animals and fish and wildlife are as yet little understood. Over 500 million pounds of synthetic organic pesticides alone are produced annually in the United States - - and their use is steadily increasing. As these toxic compounds are broadcast over the watershed, portions of them get into the runoff to streams, resulting in direct kills of fish, as well as other aquatic life, both animal and vegetable, that make up the food chain of fishes. Insidious consequences of prolonged exposure to small quantities of insecticides has been observed in small animals and birds. Experiments by the Fish and Wildlife Service and the Public Health Service have indicated that quail exposed to insecticides produced eggs that were largely infertile and chicks that were often weak, resulting in a decimation of the population. The ingestion of small amounts of these toxins by humans over long periods of time is a serious concern of the health authorities; intensive research by the Public Health Service has been underway since 1950.

4. Radioactive substances may reach a stream from several sources: waste products from mining and refining radioactive minerals; and waste products from the use of refined radioactive substances (in power reactors or for industrial, medical or other research purposes). Three major factors determine the importance of any specific radioactive waste:

    a. The quantity of radioactive material discharged will determine the concentration in the receiving waters;

    b. The duration of exposure from radioactive waste discharges (intermittent as continuous processes, kind of emission, half-life of substance involved, and the relative sensitivity of the human organ affected to the material); and

    c. The degree of hazard from the specific radioactive material. The maximum permissible concentration of radium in a domestic water supply, as recommended by the National Committee on Radiation Protection and Measurement, is 4.0 micro micrograms per liter whereas that for strontium 90 is only 0.5 micro micrograms per liter. (Expressed as a decimal, one micro microgram is 0.000 000 000 001 gram). These are upper limits, and the National Committee on Radiation Protection has urged that actual concentrations be kept as far below these values as is economically and reasonably possible.

5. Heat contained in used cooling waters from steam-electric power plants, steel mills, petroleum refineries and various other industrial plants affects the quality of receiving waters in several ways. It decreases the capacity of the receiving waters for containing oxygen and thus

reduces the ability to assimilate oxygen-demanding pollution; it has a direct detrimental effect upon fish and other aquatic life because it changes their physical environment; and it may cause stratification of water in receiving impoundments during summer months.

The Public Health Service, in cooperation with other Federal, State, and local agencies, has operated a National Water Quality Network since October 1957. Although the Network does not include any stations within the USSC-T area, a listing of analyses recorded by the Network is pertinent to any discussion of water quality. The following examinations are made on a weekly to monthly schedule: (a) radioactivity, (b) plankton organisms, (c) coliform organisms, (d) organic chemicals, (e) biochemical oxygen demand, dissolved oxygen, chemical oxygen demand, chlorine demand, ammonia, nitrogen, hydrogen ion concentration, color, turbidity, temperature, alkalinity (or acidity), hardness, chloride, sulfates, and dissolved solids.

Range of Water Quality Requirements

There is no single standard of quality that will satisfy all municipal and industrial water uses. Classification of quality requirements must be based on the desired use to be made of the water. Upper limits of impurities for three major municipal and industrial uses will now be discussed and tabulated in Tables 1, 2, and 3. Actual industrial requirements vary from the low quality of sea water to the ultimate in high quality, distilled water.

Municipal water should come from a source that is feasibly treatable to comply with the following requirements for finished water:

1. That it shall contain no organisms which cause disease.
2. That it shall be sparkling, clear, and colorless.
3. That it shall be good-tasting, free from odors, and preferably cool.
4. That it be reasonably soft.
5. That it be neither scale-forming nor corrosive.
6. That it be free from objectionable gas, such as hydrogen sulfide, and objectionable minerals such as iron and manganese.
7. That no chemicals or radioactive materials be present in harmful concentrations.

Numerical upper limits of impurities have been established by the Public Health Service for drinking water and adopted by the Texas State Department of Health.* Conformance with these limits is mandatory for water supply systems that are used by interstate carriers and enterprises that are subject to Federal Quarantine Regulations.

*U. S. Public Health Service, "Public Health Service Drinking-Water Standards," Pub.Health Rept., 61, 371 (1946).

Table 1

Upper Limits of Impurities
Public Health Service Standards

Impurity	Upper Limit
Required	
Coliform bacteria	1 per 100 ml
Turbidity	10 ppm
Color	20 ppm
Lead	0.1 ppm
Fluoride	1.5 ppm
Arsenic	0.05 ppm
Selenium	0.05 ppm
Chromium hexavalent	0 05 ppm
Recommended	
Copper	3.0 ppm
Iron and manganese (together)	0 3 ppm
Magnesium	125 ppm
Zinc	15 ppm
Chloride	250 ppm
Sulfate	250 ppm
Phenol	0.001 ppm
Total solids	500 - 1000 ppm
Alkalinity, total	35 ppm plus hardness

Example of High Quality Industrial Requirement

One use of water that practically all industries have in common is for boiler operation. The quality requirements of boiler-feed water are shown in Table 2, and cooling water requirements are shown in Table 3.

Table 2

Limits of Tolerance for Boiler-Feed Waters
(Units are in parts per million, except as otherwise noted)

Pressure (psi)	0-150	150-250	250-400	Over 400
Turbidity	20	10	5	1
Color	80	40	5	2
Oxygen consumed	15	10	4	3
Dissolved oxygen**	1.4	0.14	0.0	0.0
Hydrogen sulfide*	5	3	0	0
Total hardness ($CACO_3$)	80	40	10	2
Sulfate-carbonate ratio (ASME) Na_2SO_4: Na_2CO_3)	1:1	2:1	3:1	3:1
Aluminum oxide	5	0.5	0.05	0.01
Silica	40	20	5	1
Bicarbonate**	50	30	5	0
Carbonate	200	100	40	20
Hydroxide	50	40	30	15
Total solids (a)	3000-500	2500-500	1500-100	50
pH value (Min.)	8.0	8.4	9.0	9.6

*Except when odor in live stream would be objectionable
**Limits applicable only to feed water entering boiler, not to original water supply.
(a) Depends on design of boiler

Example of Low Quality Industrial Requirement

Cooling water should have initial temperatures less than 75 degrees Fahrenheit, should not deposit scale, be corrosive, or encourage the growth of slimes. Sea water is often used for once-through systems.

Table 3

Limits of Tolerance for Cooling Water

Constituent	Limiting Concentration
Turbidity	50 ppm
Hardness	50 ppm
Iron	0.5 ppm
Manganese	0.5 ppm
Iron and Manganese	0.5 ppm
pH	6.5 - 7.5

Proposed Water Quality Criteria for USSC-T Use

The Water Quality Collaboration Group of the USSC-T (Group #4, Meeting 2, February 17, 1960) has proposed the following Water Quality Criteria for purposes of planning.

"In order to assure maximum utilization of available surface waters, the following criteria should prevail:

a. No excessive bacterial or radiological contamination;
b. No excessive deposits in the streams;
c. No concentration of any chemical, chemical compound or combinations thereof which interferes with any legitimate downstream use;
d. No objectionable floating materials.

The objective for the future is to maintain the best quality of water possible. Realizing that water re-use generally will tend to result in some degradation of water quality, the following guidelines as to limiting concentrations in the water course are used only for the purpose of planning

Coliform Bacteria (MPN/100 ml)	1000 or less
Dissolved Oxygen	Not less than 4.0 ppm
pH	6.0 to 8.5
Total Dissolved Solids	1000 ppm or less
Chlorides	250 ppm or less
Sulfates	250 ppm or less
Color	20 or less
Iron	0.5 ppm or less
Manganese	0.1 ppm or less
Phenol	0.005 ppm or less
Fluorides	1.0 ppm or less
Boron	0.5 ppm or less
Nitrate	20 ppm or less

"The above list is not intended to be complete. Other guidelines will be applied as they become established."

Water Quality Requirements for Other Major Uses

The above-tabulated quality requirements for municipal water supplies, industrial boiler-feed water, and industrial cooling water will apply to all industrial-metropolitan areas. Impurity tolerance limits for the major industrial uses anticipated in the study area, as well as irrigation, recreation, and stockwatering, will now be described under their corresponding headings. It should be noted that the critical requirements of some industries preclude furnishing such quality either from the stream or from a municipal treatment plant; as an example, waters of a very low mineral content, although needed in many industrial processes, would be corrosive to public water systems. Fortunately, the general demands for quality by most industries are consistent with the general demands of the public for a clear, attractive water of moderate mineral content, free from iron and manganese

1. Mining

Mining (oil, natural gas, sulfur, iron and coal)

59% Process
39% Cooling — About 59% of the water used in the mining industry is for processing, and 39% for cooling.

Waters used for oil well flooding should be free from turbidity, iron, manganese, hydrogen sulfide, and low in calcium carbonate.

Mechanical mining of coal requires a clear water that is non slime-forming. (Shale fines combine with slimes and coal to produce a high ash content)

2. Primary Metal Products

Primary Metal Products — (aluminum, iron, steel, magnesium, tin, zinc).

77% Cooling
20% Process — About 20% of the water used in this industry is for processing, and 77% for cooling.

Process water quality requirements may be considered similar to those for the transportation equipment industries.

Desirable quality characteristics in the water supply for steel manufacture include:

1. Temperature below 75° F.
2. Chlorides below 175 parts per million.
3. pH between 6.8 and 7.0.
4. Hardness below 50 parts per million.
5. Suspended matter below 25 parts per million.
6. Organic content as low as possible.
7. Corrosion potential as low as possible.

3. Transportation Equipment

Centered in Fort Worth and Dallas Area

52% Cooling water
42% Process water

Electroplating process water is used for cleaning, rinsing after cleaning, making up plating batts, and rinsing after plating. Water of zero hardness is required for all stages. Turbidity and iron are objectionable, as are chlorides and sulfates; free carbon dioxide should not exceed 15 ppm.

4. Stone Clay and Glass Products

(Quarries, sand washing, ceramics, cement, glass)

32% Cooling
64% Processing

Ceramics

Process water should be clear, low in color, free from iron, manganese, organic growth, low in dissolved minerals, and of constant composition.

5. Food and Kindred Products

(Canning, citrus, dairy, fermentation, meat)

62% Cooling
38% Processing

Bottles (Carbonated beverages)

Free from iron, manganese, turbidity, color, taste and odor and of satisfactory bacteriological quality. Low in alkalinity (less than 50 ppm). Bottle washing, general purposes and boiler-feed water should be soft, (preferably zero hardness). Although municipal waters usually are used, even these are treated through sand and activated carbon filters

Breweries

Brew water should be clear, colorless, odorless, tasteless, free from iron and manganese, and bacteriologically acceptable. Low bicarbonates and high sulfates are desirable (calcium sulfate is sometimes added to increase the sulfates to 200-250 ppm).

Distilleries

Clear, colorless, free from iron, manganese, foreign tastes and odors, and of approved bacteriological quality. Some hardness is usually desirable in the water used for mashing, and moderate amounts of bicarbonate hardness are frequently of value as a buffer in maintaining the proper pH value during fermentation.

Distilled water is needed for deproofing.

Food (general)

Process waters should be clear, colorless, free from iron, manganese, and objectionable tastes and odors, and especially of approved bacteriological quality.

Requirements for specific food industries not only vary widely but are sometimes conflicting. High sulfate hardness that makes water desirable for the fermentation industry, makes it unusable for canning peas, beans, or lentils.

Canneries

Process water for canning should be clear and colorless; free from iron, manganese, and objectionable tastes and odors; and of approved bacteriological quality Water used for canning peas, beans, and lentils should be free from hardness, since hardness combines with some of the protein matter, making the product tougher and decreasing its grade. Hardness does not affect fruits or most other acid products Alkalinity exceeding 50 ppm in waters used for sterilizing processing may cause the outside of the cans to have a spangled appearance

Citrus Fruit Industry

Soft water is preferred for washing citrus fruits for better cleansing and improved appearance of the product.

Dairies

The dairy industry requires water that is clear, colorless, free from iron, manganese, taste and odors; sterile; and of zero hardness About 40 to 50 per cent of this water is heated.

Ice Manufacturing

Water used in making commercial ice should be clear, colorless, odorless, tasteless, free from iron and manganese, of approved bacteriological quality, and of low mineral salt content. Bicarbonate hardness should be less than 70 ppm.

Meat Packing Plants

Water used should be clear, colorless, odorless, tasteless, free from iron or manganese and of approved bacteriological quality. Alkaline washing operations should have waters of zero hardness.

Edible Oil Refineries

These refineries produce salad and cooking oils; hydrogenated oils for shortening and cooking; soaps; synthetic wetting agents; and detergents. Process water should be clear, colorless, odorless, tasteless, free from iron and manganese, and of approved bacteriological quality.

Starch and Corn Products

Process water must be free from iron and manganese, and be relatively soft, as well as being clear, colorless, odorless, tasteless, and of approved bacteriological quality.

Sugar Refineries

The following threshold concentrations are recommended:

Constituent	Concentrations (ppm)
Calcium	20
Magnesium	10
Sulfate	20
Chloride	20
Bicarbonate	100
Iron	0.1

6 Textile Mill Products

Wool Scouring, Wool Dyeing, Cotton

Cooling water insignificant

The wet processing of textiles requires water that is free from turbidity, color, iron, manganese, hardness, and organic growths, and non-corrosive.

Numerical tolerance limits for the above may be set at:

Color - 5 10 ppm
Iron - 0.1 ppm
Manganese - 0.05 ppm
Hardness - Zero

Organic growths such as algae, crenothrix, molds, and slimes are very objectionable as they cause clogging, staining, odors, and wastage.

7. Paper and Allied Products

(Presently in Dallas, Lufkin, and Houston - water survey area).

1. Pulp and Paper Milling
2 Manufacture of connected paper products
96.5% used as process water

The Technical Association of the Pulp and Paper Industry has proposed the following tentative tolerances for turbidity, color, iron and manganese:

Impurity	Std. for Higher-Grade Products	Std. for Lower-Grade Products
Turbidity (ppm)	5.0	25
Color (ppm)	5.0	15
Iron (ppm as Fe)	0.1	0.2
Manganese (ppm as Mg	0.05	0.1

Free carbon dioxide should not exceed 25 ppm as it will affect sheet formation on paper machines. The water should be free from corrosive hydrogen sulfide, color and odor. Calcium hardness should not exceed 35 ppm.

8. Chemical and Allied Products

(Principally Petrochemical)

Majority of water consumption in Houston and Victoria water survey areas.

72% Cooling water
24% Process water

Most chemical manufacturing processes use large quantities of steam for heating, processing, generation of electricity, or directly for plant operations. Modern trend is to high pressure boilers to furnish pressures as needed.

Process Waters - clear, colorless and free from iron, manganese, hydrogen sulfide and organic growths. Additional tolerance limits depend on the chemicals being produced, to the extreme requirement of distilled water for chemically pure chemicals, drugs, and pharmaceuticals.

9. Petroleum and Coal Products

Petroleum Refining - centered in Houston and Corpus Christi water survey areas.

57% Cooling water
40% Process water

Process water is primarily for steam production, and quality requirements are as for boiler-feed water.

10. Agriculture (Irrigation and Stock Watering)

A unique quality requirement of irrigation waters as compared to municipal and industrial requirements is that based on the sodium absorption ratio. The sodium absorption ratio is obtained by dividing the sodium content of a water by one-half of the square root of the sum of its calcium and magnesium. A value of 8-10 is generally considered safe; it should not exceed 20.

This requirement is significant since excessive values will cause most soils to become impermeable, hard, and sticky. Boron as boric acid should not exceed 0.3 to 1.0 parts per million for sensitive crops, nor 2.0 to 4.0 ppm for tolerant crops.

For highest production of stock, water quality used in stock watering should equal that for domestic consumption.

Death of cattle (and other animals) has occurred when they consumed water laden with certain genera of blue-green algae. (Cyanophyta species).

11. Recreation

Waters to be acceptable for swimming and bathing should conform to three general conditions: (a) be esthetically enjoyable, i.e., free from obnoxious floating or suspended substances, objectionable color, and foul odors; (b) contain no substances that are toxic upon ingestion or irritating to the skin, and (c) be reasonably free from pathogenic organisms. The quality criteria proposed for USSC-I use should be satisfactory for any recreational use.

QUANTITY AND QUALITY OF RETURN FLOWS

Method of Estimating Quantity and Quality of Return Flows

The determination of the quantity and quality of return flows was divided into two phases. One phase was a consideration of municipal wastes, while the other was a consideration of industrial wastes. Projected municipal and industrial water quantity requirements are contained in the Bureau of Reclamation Reports for the nine study areas of the Commission.* The water requirements contained in the reports formed a basis upon which the return flow calculations were made.

Municipal return-flow quantities were determined by applying sewage-to-water-use ratios, contained in the report, Water Re-Use in Texas, by E F. Gloyna dated June 30, 1957, to the predicted water requirements for each area under study; modifications were made as indicated by current records and recommendations of the Texas State Department of Health. The quantities of biochemical oxygen demand, mineral matter, and organic matter contained in the municipal return flows were determined by applying waste loading factors which are characteristic of municipal wastes to population projections supplied by the Bureau of Reclamation. The factors had the units of pounds of constituent per day per capita, and the results were reported as tons per year of each constituent.

In the determination of the quantities of return flows from industries, the quantities of water used by industries in 1958 in the various areas under study were supplied by the Bureau of Business Research of the University of Texas. Ratios of water used by various types of industry were developed from these data. These ratios were then applied to the projected industrial water requirements contained in the Bureau of Reclamation reports to obtain the quantities of water required by various types of industries, assuming the relationship of water uses will remain constant between the various types of industries. The ratios of return flow to water use for various broad categories of industry were obtained from the report Water Re-Use in Texas and applied to the requirements projections to obtain the quantities of return flows

The amounts of biochemical oxygen demand, mineral matter and organic matter contained in the industrial return flows were determined by applying concentration factors which are considered characteristic for various types of industries to the quantities of return flow for the corresponding industries

A final tabulation shows the total tons per year of each category of pollutant after treatment. For purposes of this study, it is assumed that:

1. Municipal wastes will be treated to remove at least 90 per cent of the putrescible organic material as measured by the five day BOD test.

2 Organic industrial wastes will be treated to provide an effluent of a quality equivalent to treated municipal wastes as in item one above.

3. Inorganic wastes will be treated to reduce the concentration to acceptable limits. Wastes for which satisfactory treatment methods are not known will not be discharged to a watercourse.

4. Discharges of cooling water and wastes will not be permitted to cause a detrimental increase in the temperature of the receiving water.

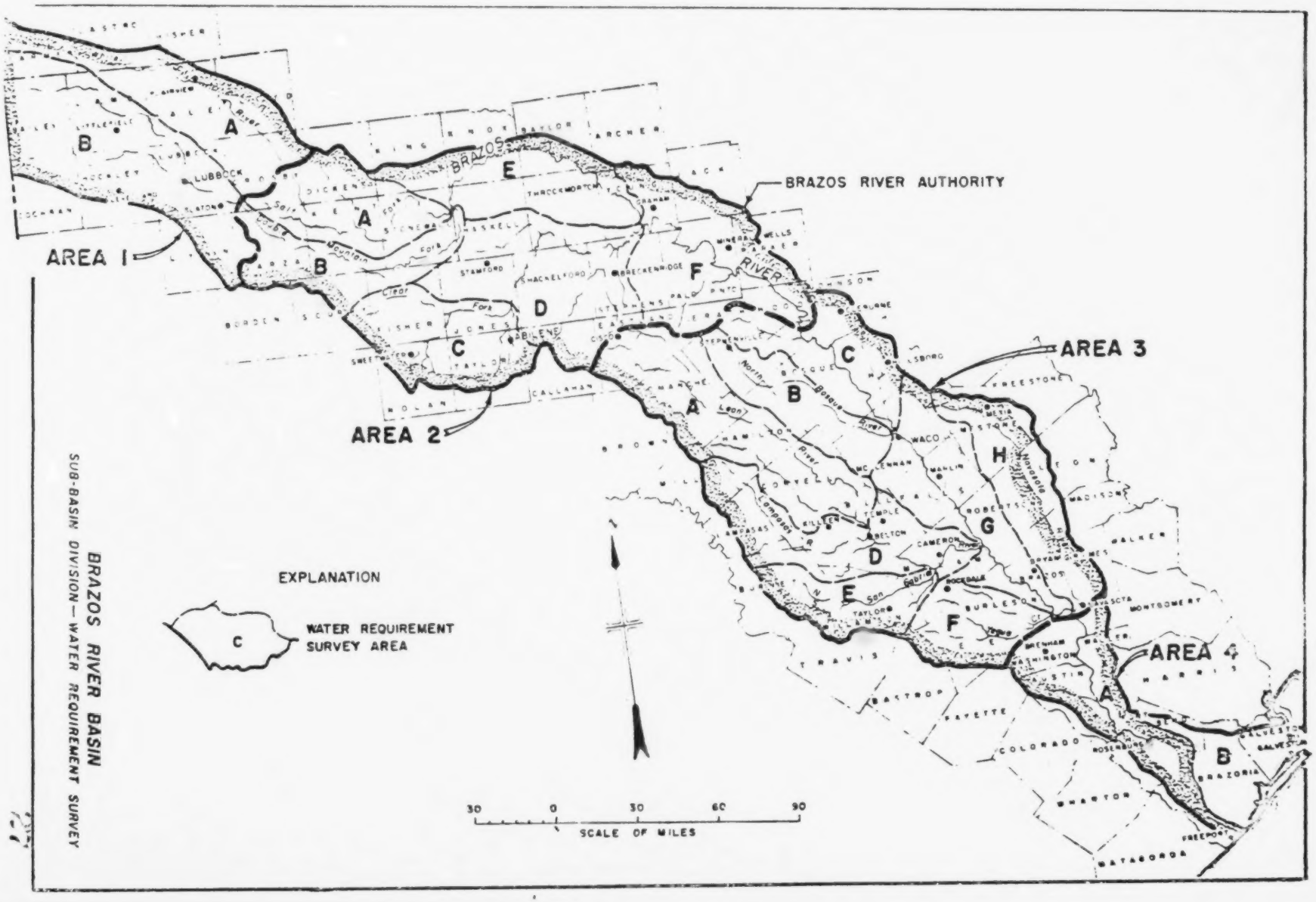
Since only about 15 per cent reduction in minerals can be accomplished by currently economically feasible methods, treated return flows will be assumed to have 85 per cent of the untreated waste concentration. It should be noted that the minerals may be kept out of the stream by diverting the return flows to land disposal or injection wells, but the wastes would not then be classed as "return" flows.

Tabular Format

In the Bureau of Reclamation Reports for the nine study areas of the Commission,* a quantitative projection of water requirements is made for the years 1975 and 2010. The format used in presenting those quantitative projections was based on a subdivision of the study area into water survey areas, with a tabulation of municipal and industrial requirements shown for each of those subareas.

This report describes the quantity and quality of return flows that may be expected to correspond with the projected requirements as tabulated in the above reports, and the same format is used herein.

*(1) Brazos River
(2) Colorado River
(3) Guadalupe River
(4) Lower Rio Grande Valley
(5) Neches River
(6) Nueces River
(7) San Jacinto River
(8) San Antonio River
(9) Trinity River


BRAZOS RIVER AUTHORITY
AREA 1
AREA 2
AREA 3
AREA 4
BRAZOS RIVER
EXPLANATION
C
WATER REQUIREMENT SURVEY AREA
30 0 30 60 90
SCALE OF MILES
BRAZOS RIVER BASIN
SUB-BASIN DIVISION—WATER REQUIREMENT SURVEY

BRAZOS RIVER BASIN

Entire Basin

The Brazos River is 898 miles long and drains an area of 44,222 square miles. The total population is expected to be 2,168,800 by the year 1975 and 3,292,800 by the year 2010. Corresponding water requirements for combined municipal and industrial uses are expected to increase to 243,451 million gallons per year (MGY) and 488,964 MGY, respectively.

Return flows will total approximately 156,910 MGY in 1975 and 314,550 MGY in 2010. In 1975, after treatment, the return water will have an incremental constituent load of 20,410 tons of biochemical oxygen demand, 250,170 tons of minerals, and 26,250 tons of organics. By 2010 the treated incremental load will include 40,130 tons of biochemical oxygen demand, 421,490 tons of minerals, and 49,320 tons of organics.

Using minerals as an indicator of the major source of quality-related constituents, about 19 35 per cent will originate in Area 4B, 18-16 per cent will originate in Area 4A, and 17-15 per cent will originate in Area 1B by the years 1975 and 2010, respectively.

Area 1B - Nonindustrial

This 4,850 square-mile area is drained by Double Mountain Fork, a headwaters tributary of the Brazos River, and includes the cities of Levelland, Littlefield, Lubbock and Slaton.

In 1975, a treated noninudstrial return flow of 13,470 MGY will have an incremental constituent load of 1,660 tons of biochemical oxygen demand, 13,040 tons of minerals, and 2,130 tons of organics. By the year 2010, the incremental constituent load will include 2,320 tons of biochemical oxygen demand, 18,130 tons of minerals, and 2,960 tons of organics in a return flow of 21,770 MGY

Area 1B Industrial

Existing and/or expected future industrial activities include Petroleum refining, food processing, and manufacture of chemical fertilizers.

In the year 1975, treated industrial return flows are expected to total 2,130 MGY, with an incremental constituent loading of 320 tons of biochemical oxygen demand, 29,850 tons of minerals, and 420 tons of organics. By the year 2010, the treated industrial return flow is expected to total 3,220 MGY, with an incremental constituent loading of 480 tons of biochemical oxygen demand, 45,300 tons of minerals, and 630 tons of organics.

Area 4A - Nonindustrial

This 2,000 square mile area drains into the Brazos River from river mile 232 to the mouth. It includes the cities of Freeport, Rosenburg, and Brenham.

In 1975, a treated nonindustrial return flow of 5,450 MGY will have an incremental constituent load of 880 tons of biochemical oxygen demand, 6,900 tons of minerals, and 1,130 tons of organics. By the year 2010, the incremental

constituent load will include 1,430 tons of biochemical oxygen demand, 11,210 tons of minerals, and 1,840 tons of organics in a return flow of 12,160 MGY.

Area 4A - Industrial

Existing and/or future industrial activities include the manufacture of organic and inorganic chemicals, sulfur mining, food processing, and textiles.

In the year 1975, treated industrial return flows are expected to total 43,860 MGY, with an incremental constituent loading of 4,420 tons of biochemical oxygen demand, 38,040 tons of minerals, and 5,710 tons of organics. By the year 2010, the treated industrial return flow is expected to total 62,670 MGY, with an incremental constituent loading of 8,140 tons of biochemical oxygen demand, 55,040 tons of minerals, and 8,170 tons of organics.

Area 4B - Nonindustrial

This 1,382 square-mile area adjoins the Brazos River Basin and drains into tidal waters. It includes the city of Galveston.

In 1975, a treated nonindustrial return flow of 8,690 MGY will have an incremental constituent load of 1,170 tons of biochemical oxygen demand, 9,160 tons of minerals, and 1,500 tons of organics. By the year 2010, the incremental constituent load will include 2,450 tons of biochemical oxygen demand, 19,160 tons of minerals, and 3,140 tons of organics in a return flow of 19,940 MGY.

Area 4B - Industrial

Existing and/or future industrial activities include petroleum refining, food processing (shrimp, tea, malt liquors, and meat), and the manufacture of pharmaceuticals, organic chemicals, and fertilizer

In the year 1975, treated industrial return flows are expected to total 30,100 MGY, with an incremental constituent loading of 4,530 tons of biochemical oxygen demand, 39,680 tons of minerals, and 5,840 tons of organics By the year 2010, the treated industrial return flow is expected to total 97,630 MGY, with an incremental constituent loading of 14,680 tons of biochemical oxygen demand, 129,070 tons of minerals, and 18,940 tons of organics.

TABLE 3-1
AREA AND POPULATION DATA
BRAZOS RIVER BASIN AND ADJOINING AREAS

Area	River Reach (mi.)	River Miles	Area (sq. mi.)	Population 1975	Population 2010	Population Density (per sq. mi.) 1975	Population Density (per sq. mi.) 2010
1-A	-	-	2,590	83,500	101,700	32.24	39.27
1-B	-	-	4,850	365,200	508,000	75.29	104.74
2-A	-	-	2,269	27,200	35,000	11.99	15.43
2-B	-	-	1,779	15,100	14,300	8.49	8.04
2-C	-	-	2,220	143,400	175,000	64.59	78.83
2-D	-	-	3,544	43,800	42,500	12.36	11.99
2-E	756-898	142	2,548	15,500	12,300	6.08	4.83
2-F	520-756	236	3,240	57,300	74,800	17.69	23.09
3-A	-	-	3,513	55,400	53,200	15.77	15.14
3-B	-	-	1,639	48,800	40,000	29.77	24.41
3-C	406-520	114	2,021	73,400	76,800	36.31	38.00
3-D	-	-	2,655	161,000	204,500	60.64	77.02
3-E	-	-	1,327	44,000	50,300	33.16	37.91
3-F	-	-	1,112	49,800	69,400	44.78	62.41
3-G	232-406	174	3,374	491,500	941,200	145.67	27.90
3-H	-	-	2,159	44,000	42,600	20.38	19.73
4-A	0-232	232	2,000	193,200	314,200	96.60	157.10
4-B	-	-	1,382	256,700	537,000	185.75	388.56
			44,222	2,168,800	3,292,800		

Note: Listing of main streams for all areas, other than Brazos River.

Area 1-A White River.

Area 1-B Double Mountain Fork.

Area 2-A Salt Fork.

TABLE B-1 (Cont'd)

Area 2-B Double Mountain Fork

Area 2-C Clear Fork.

Area 2-D Double Mountain and Clear Fork.

Area 3-A Leon River, South Fork, Cowhouse Creek.

Area 3-B Bosque River, Northland South Bosque River.

Area 3-D Little River, Lampasas River, Leon River.

Area 3-E San Gabriel River, Brushy Creek.

Area 3-F Yequa Creek.

Area 3-H Navasota River.

Area 4-B This is an adjoining area and drains into tidal waters.

Mileage for streams other than Brazos River is not available at this time.

TABLE B-1 (Cont'd)

Area 2-B Double Mountain Fork.

Area 2-C Clear Fork.

Area 2-D Double Mountain and Clear Fork.

Area 3-A Leon River, South Fork, Cowhouse Creek.

Area 3-B Bosque River, Northland South Bosque River.

Area 3-D Little River, Lampasas River, Leon River.

Area 3-E San Gabriel River, Brushy Creek.

Area 3-F Yequa Creek.

Area 3-H Navasota River.

Area 4-B This is an adjoining area and drains into tidal waters.

Mileage for streams other than Brazos River is not available at this time.

TABLE B-2

MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
BRAZOS RIVER BASIN AND ADJOINING AREAS

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
Area 1										
A										
Plainview	2,138	1,460	160	1,210	200	3,506	2,220	210	1,610	260
Other	3,020	2,060	230	1,770	290	4,453	2,820	260	2,020	330
Subtotal	5,158	3,520	460	9,660	570	7,959	5,040	540	10,800	690
Industrial	536	510	70	6,680	80	585	530	70	7,170	100
Nonindustrial	4,622	3,010	390	2,980	490	7,374	4,510	470	3,630	590
B										
Levelland	1,037	700	80	610	100	1,702	1,090	100	810	130
Littlefield	732	500	50	430	70	1,219	780	70	580	90
Lubbock	15,098	10,240	1,070	8,390	1,370	28,899	18,500	1,560	12,180	1,990
Slaton	671	460	50	390	60	1,243	800	80	590	100
Other	5,450	3,790	410	3,220	530	5,970	3,820	510	3,970	650
Subtotal	22,988	15,690	1,930	42,890	2,550	39,033	24,990	2,800	63,430	3,590
Industrial	2,303	2,130	320	29,850	420	3,462	3,220	480	45,300	630
Nonindustrial	20,685	13,470	1,660	13,040	2,130	35,571	21,770	2,320	18,130	2,960
Total Area 1										
Total	28,146	19,120	2,440	52,550	3,120	46,992	30,030	3,340	74,230	4,280
Industrial	2,839	2,640	390	36,530	500	4,047	3,750	550	52,470	730
Nonindustrial	25,307	16,480	2,050	16,020	2,620	42,945	26,280	2,790	21,760	3,550
Area 2										
A										
Subtotal	2,734	2,170	290	24,470	380	3,830	2,790	340	25,290	430
Industrial	1,294	1,230	170	23,500	220	1,329	1,260	180	24,040	230
Nonindustrial	1,440	940	120	970	160	2,501	1,530	160	1,250	200
D										
Subtotal	4,206	3,180	400	5,620	520	6,644	4,790	520	7,350	660
Industrial	2,641	2,160	330	5,080	430	3,566	2,910	450	6,840	580
Nonindustrial	1,565	1,020	70	540	90	3,078	1,880	70	510	80
C										
Abilene	6,357	4,370	460	3,570	580	10,697	7,030	650	5,070	830
Sweetwater	1,897	1,310	90	710	120	3,077	2,020	110	860	140
Other	2,201	1,520	110	840	140	1,985	1,310	40	310	50
Subtotal	10,455	7,200	850	12,220	1,090	15,759	10,360	1,100	14,980	1,410
Industrial	1,723	1,520	190	7,100	250	2,628	2,320	300	8,740	390
Nonindustrial	8,732	5,680	660	5,120	840	13,131	8,040	800	6,240	1,020

TABLE B-2 (Cont'd)
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
BRAZOS RIVER BASIN AND ADJOINING AREAS (Continued)

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
D										
Breckenridge	679	470	40	320	50	1,035	680	50	420	70
Stamford	455	310	30	250	40	625	410	40	300	50
Other	2,056	1,420	130	990	160	2,510	1,650	100	800	130
Subtotal	3,190	2,200	280	4,670	350	4,170	2,740	300	5,600	390
Industrial	739	600	80	3,110	100	1,026	820	110	4,080	140
Nonindustrial	2,451	1,600	200	1,560	250	3,144	1,920	190	1,520	250
E										
Subtotal	1,169	870	100	970	140	1,494	1,110	110	2,810	150
Industrial	360	340	30	420	50	598	560	50	2,370	80
Nonindustrial	809	530	70	550	90	896	550	60	440	70
F										
Graham	630	410	50	360	60	1,109	680	70	530	90
Mineral Wells	1,343	870	80	590	100	2,215	1,350	120	960	160
Other	1,718	1,120	140	1,100	180	2,275	1,390	150	1,170	190
Subtotal	3,691	2,400	280	2,140	350	5,599	3,420	350	2,790	460
Industrial	96	60	10	90	10	174	100	10	130	20
Nonindustrial	3,595	2,340	270	2,050	340	5,425	3,320	340	2,660	440
Total Area 2										
Total	25,445	18,020	2,200	50,090	2,830	37,496	25,210	2,720	58,820	3,590
Industrial	6,853	5,910	810	39,300	1,060	9,321	7,970	1,100	46,200	1,440
Nonindustrial	18,592	12,110	1,390	10,790	1,770	28,175	17,240	1,620	12,620	2,060
Area 3										
A										
Cisco	762	490	30	250	40	926	1,400	40	300	50
Other	2,316	1,470	220	1,730	280	3,018	4,560	200	1,600	260
Subtotal	3,078	1,960	260	2,120	330	3,944	5,960	250	2,130	420
Industrial	62	40	10	140	10	85	60	10	230	10
Nonindustrial	3,016	1,920	250	1,980	320	3,859	5,900	240	1,900	310
B										
Stephenville	869	780	50	390	60	1,367	850	80	620	100
Other	1,610	760	170	1,350	220	1,535	950	100	810	130
Subtotal	2,479	1,540	220	1,740	280	2,902	1,800	180	1,430	230
Industrial	---	---	---	---	---	---	---	---	---	---
Nonindustrial	2,479	1,540	220	1,740	280	2,902	1,800	180	1,430	230

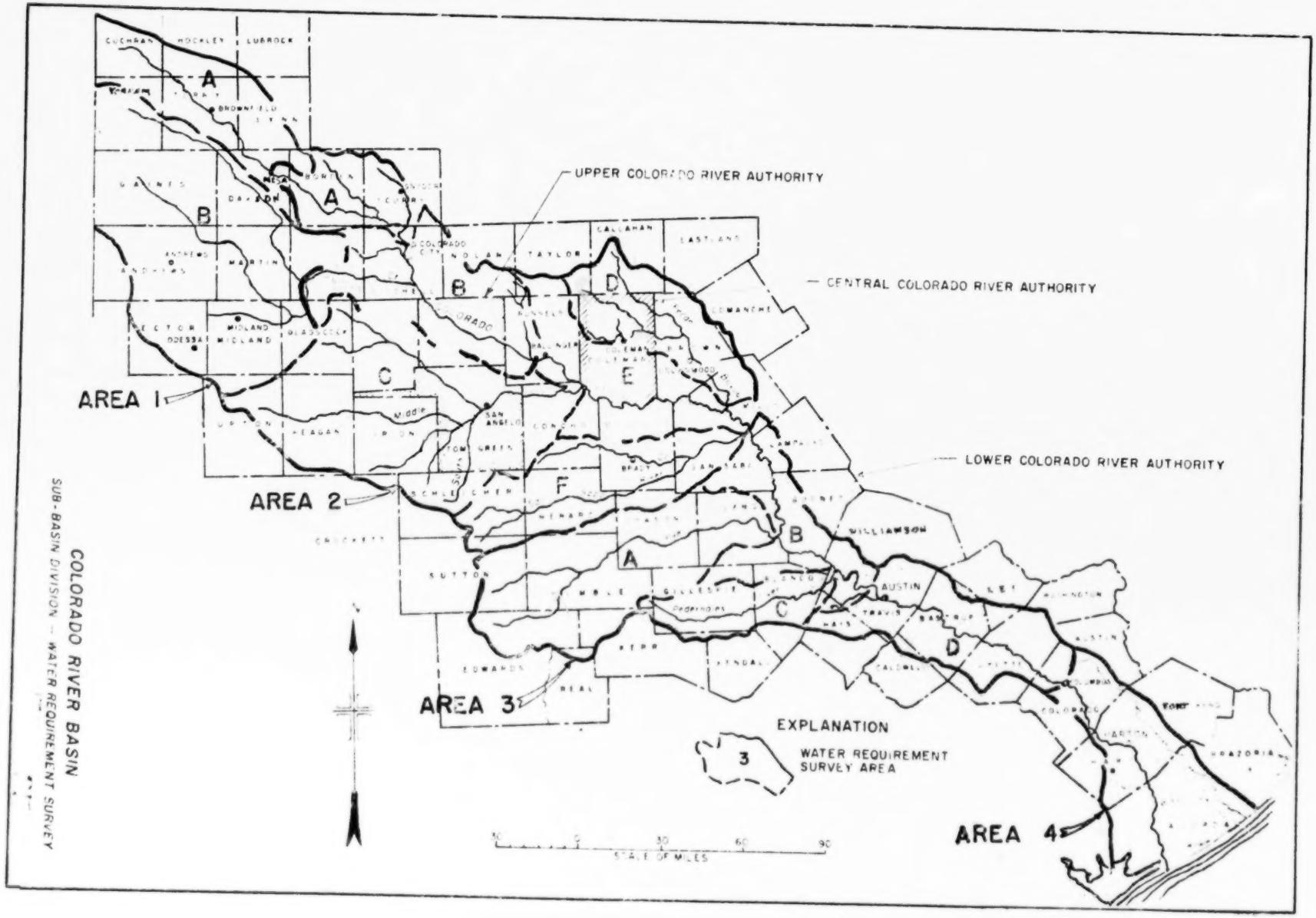

UPPER COLORADO RIVER AUTHORITY
CENTRAL COLORADO RIVER AUTHORITY
LOWER COLORADO RIVER AUTHORITY
AREA 1
AREA 2
AREA 3
AREA 4
EXPLANATION
3
WATER REQUIREMENT SURVEY AREA
SCALE OF MILES
COLORADO RIVER BASIN
SUB-BASIN DIVISION — WATER REQUIREMENT SURVEY

TABLE B-2 (Cont'd)
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
BRAZOS RIVER BASIN AND ADJOINING AREAS (Continued)

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
C										
Cleburne	1,176	730	100	760	120	2,259	1,400	150	1,200	200
Hillsboro	624	390	60	450	70	1,314	820	90	690	110
Other	1,708	1,060	180	1,410	230	1,607	1,000	110	850	140
Subtotal	3,508	2,180	340	2,750	420	5,180	3,220	350	3,010	450
Industrial	61	40	---	130	---	108	80	---	270	---
Nonindustrial	3,447	2,140	340	2,620	420	5,072	3,140	350	2,740	450
D										
Belton	1,209	810	60	500	80	2,635	1,760	120	900	150
Cameron	386	260	40	290	50	635	430	40	340	60
Killeen	915	610	100	790	130	1,377	920	100	790	130
Temple	3,055	2,040	230	1,760	290	7,513	5,030	420	3,290	540
Other	3,509	2,350	310	2,410	400	2,936	1,970	250	1,980	330
Subtotal	9,074	6,070	890	21,690	1,140	15,096	10,110	1,090	24,030	1,410
Industrial	1,441	1,340	150	15,940	190	1,462	1,660	160	16,730	200
Nonindustrial	7,633	4,730	740	5,750	950	13,634	8,450	930	7,300	1,210
E										
Taylor	701	300	60	480	80	1,424	500	100	760	120
Other	1,519	640	140	1,090	180	1,934	680	130	1,040	170
Subtotal	2,220	940	200	1,590	260	3,358	1,180	230	1,830	290
Industrial	71	40	---	20	---	141	70	---	30	---
Nonindustrial	2,149	900	200	1,570	260	3,217	1,110	230	1,800	290
F										
Rockdale	5,522	1,950	110	890	150	11,272	3,850	200	1,590	260
Other	2,203	780	110	890	150	3,703	1,260	110	890	150
Subtotal	7,725	2,730	220	1,780	300	14,975	5,110	310	2,480	410
Industrial	5,482	1,270	---	---	---	10,671	2,480	---	---	---
Nonindustrial	2,243	1,460	220	1,780	300	4,304	2,630	310	2,480	410
G										
Bryan	4,831	2,540	420	3,250	530	11,468	6,140	770	6,000	980
Marlin	551	290	40	350	60	1,045	560	70	510	80
Waco	21,583	11,330	1,340	12,060	1,970	56,838	30,430	3,280	25,620	4,190
Other	2,557	1,340	240	1,880	310	2,776	1,490	180	1,430	230
Subtotal	29,522	15,500	2,430	20,310	3,120	72,127	38,620	4,760	37,340	6,080
Industrial	3,709	2,030	190	2,770	250	8,454	5,760	460	3,780	600
Nonindustrial	25,813	13,470	2,240	17,540	2,870	63,673	32,860	4,300	33,560	5,480

TABLE B-2 (Cont'd)
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
BRAZOS RIVER BASIN AND ADJOINING AREAS (Continued)

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
H										
Mexia	479	250	50	380	60	966	510	70	550	90
Navasota	302	160	30	230	40	562	290	40	310	50
Other	643	340	120	960	160	212	110	80	660	110
Subtotal	1,424	750	210	1,770	270	1,740	910	200	1,710	260
Industrial	42	30	10	200	10	39	30	10	190	10
Nonindustrial	1,382	720	200	1,570	260	1,701	880	190	1,520	250
Total Area 3										
Total	59,030	31,670	4,770	53,750	6,120	119,322	66,910	7,370	73,960	9,450
Industrial	10,868	4,790	360	19,200	460	20,960	10,140	640	21,230	820
Nonindustrial	48,162	26,880	4,410	34,550	5,660	98,362	56,770	6,730	52,730	8,630
Area 4										
A										
Freeport	60,681	40,970	470	3,680	600	97,827	66,010	1,030	8,070	1,320
Rosenburg	914	600	90	710	120	2,804	1,890	220	1,710	280
Brenham	421	300	40	330	50	798	540	60	470	80
Other	11,023	7,440	280	2,180	360	9,475	6,390	120	960	160
Subtotal	73,039	49,310	5,300	44,940	6,840	110,904	74,830	9,570	66,250	10,010
Industrial	65,059	43,860	4,420	38,040	5,710	92,142	62,670	8,140	55,040	8,170
Nonindustrial	7,980	5,450	880	6,900	1,130	18,762	12,160	1,430	11,210	1,840
B										
Galveston	55,618	37,330	1,070	8,350	1,370	172,407	115,010	2,380	18,640	3,050
Other	2,173	1,460	100	810	130	3,843	2,560	70	520	90
Subtotal	57,791	38,790	5,700	48,840	7,340	176,250	117,570	17,130	148,230	22,080
Industrial	45,066	30,100	4,530	39,680	5,840	145,471	97,630	14,680	129,070	18,940
Nonindustrial	12,725	8,690	1,170	9,160	1,500	30,779	19,940	2,450	19,160	3,140
Total Area 4										
Total	130,830	88,100	11,000	93,780	14,180	285,154	192,400	26,700	214,480	32,090
Industrial	110,125	73,960	8,950	77,720	11,550	237,613	160,300	22,820	184,110	27,110
Nonindustrial	20,705	14,140	2,050	16,060	2,630	49,541	32,100	3,880	30,370	4,980

TABLE B-2 (Cont'd)
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
BRAZOS RIVER BASIN AND ADJOINING AREAS (Continued)

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
All Areas										
Total	243,451	156,910	20,410	250,170	26,250	488,964	314,550	40,130	421,490	49,320
Industrial	130,685	87,300	10,510	172,750	13,570	271,941	182,160	25,110	304,010	30,100
Nonindustrial	112,766	69,610	9,900	77,420	12,680	219,023	132,390	15,020	117,480	19,220

(1) Assumed treatment: 90% reduction of B.O.D. (Biochemical oxygen demand) and organic matter in municipal wastes and an equivalent quality in industrial return flows.
15% reduction of mineral matter.

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COLORADO RIVER BASIN

Entire Basin

The Colorado River is 890 miles long, and drains an area of 39,900 square miles. The total population is expected to be 1,191,700 by the year 1975 and 1,694,500 by the year 2010. Corresponding water requirements for combined municipal and industrial use are expected to increase to 147,240 million gallons per year (MGY), and 275,363 MGY, respectively.

Return flows will total approximately 87,524 MGY in 1975 and 160,281 MGY in 2010. In 1975, after treatment, the return water will have an incremental constituent load of 12,230 tons of biochemical oxygen demand, 137,810 tons of minerals, and 15,800 tons of organics. By 2010, the treated incremental load will include 21,980 tons of biochemical oxygen demand, 206,350 tons of minerals, and 28,280 tons of organics.

Using minerals as an indicator of the major source of quality-related constituents, about 28 per cent originates in Area 4, and 19 per cent originates in Area 1B.

Area 1B - Nonindustrial

This 7,730 square-mile area drains into Beals Creek and Sulphur Springs Creek. It includes the cities of Andrews, Lamesa, Midland and Odessa.

In 1975, a treated nonindustrial return flow of 10,939 MGY will have an incremental constituent load of 1,340 tons of biochemical oxygen demand, 10,410 tons of minerals, and 1,700 tons of organics. By the year 2010, the incremental constituent load will include 1,880 tons of biochemical oxygen demand, 14,570 tons of minerals, and 2,390 tons of organics in 18,867 MGY return flow.

Area 1B - Industrial

Existing and/or future industrial activities include mining, natural gas and petroleum, metal products, food and kindred industries, textiles, and chemical manufacturing.

In the year 1975, treated industrial return flows are expected to total 7,984 MGY, with an incremental constituent loading of 920 tons of biochemical oxygen demand, 16,190 tons of minerals, and 1,190 tons of organics. By the year 2010, the treated industrial return flow is expected to total 13,230 MGY with an incremental constituent loading of 1,430 tons of biochemical oxygen demand, 25,000 tons of minerals, and 1,850 tons of organics.

Area 4 - Nonindustrial

This 1,638 square-mile area drains into the Colorado River from river mile 135 to the mouth. It includes the cities of Bay City and El Campo.

In 1975, a treated nonindustrial return flow of 2,732 MGY will have an incremental constituent load of 470 tons of biochemical oxygen demand, 3,640 tons of minerals, and 600 tons of organics. By the year 2010, the incremental constituent load will include 570 tons of biochemical oxygen demand, 4,440 tons of minerals, and 730 tons of organics in 4,726 MGY return flow.

Area 4 - Industrial

Existing industrial activities include food processing, petroleum refining, chemicals, and metal products.

In the year 1975, treated industrial return flows are expected to total 30,063 MGY, with an incremental constituent loading of 4,440 tons of biochemical oxygen demand, 36,410 tons of minerals, and 5,860 tons of organics. By the year 2010, the treated industrial return flow is expected to total 66,195 MGY, with an incremental constituent loading of 10,240 tons of biochemical oxygen demand, 50,710 tons of minerals, and 13,210 tons of organics.

TABLE C-1
AREA AND POPULATION DATA
COLORADO RIVER BASIN AND ADJOINING AREAS

Area	River Reach (mi.)	River Miles	Area (sq. mi.)	Population 1975	Population 2010	Population Density (per sq mi.) 1975	Population Density (per sq mi.) 2010
1-A	-	-	2,000	39,400	45,700	19.70	22.85
1-B	-	-	7,730	291,800	408,400	37 75	52.83
2-A	794-890	96	1,492	32,300	30,900	21.65	20.71
2-B	665-794	129	3,748	61,100	65,000	16.31	17.34
2-C	-	262	5,754	119,500	159,400	20.77	27.70
2-D	-	128	2,194	40,300	44,000	18.37	20.05
2-E	479-665	186	2,669	19,100	14,600	7.16	5.47
2-F	-	217	3,143	26,600	31,900	8.46	10.15
3-A	-	227	4,491	16,400	20,500	3.65	4.56
3-B	300-479	179	2,021	32,700	21,100	16.18	10.44
3-C	-	109	1,288	13,400	18,000	10.40	13.98
3-D	135-300	165	2,670	392,000	698,600	146.82	261.64
4	0-135	135	1,638	107,100	136,400	65.38	83.27
			39,893	1,191,700	1,694,500		

Note:

Sub-basin areas 2-A, 2-B, 2-E, 3-B, 3-D, and Area 4 are on the Colorado River.
Sub-basin 1-A is on Lost Draw and Sulphur Draw which drain into a normally dry lake.
Sub-basin 1-B is on Beals Creek and Sulphur Springs Creek. The mileage is not available at this time.
Sub-basin 2-C is on the Concho River with the South, Middle, and North Concho Rivers as tributaries.
Sub-basin 2-D is on the Pecan Bayou.
Sub-basin 2-F is on the San Saba River and Brady Creek. The mileage is to the junction of the North and Middle Valley Prings and all of Brady Creek.
Sub-basin 3-A is on the Llano River, with the North Llano River and South Llano River as tributaries.
Sub-basin 3-C is on the Pedernales River.

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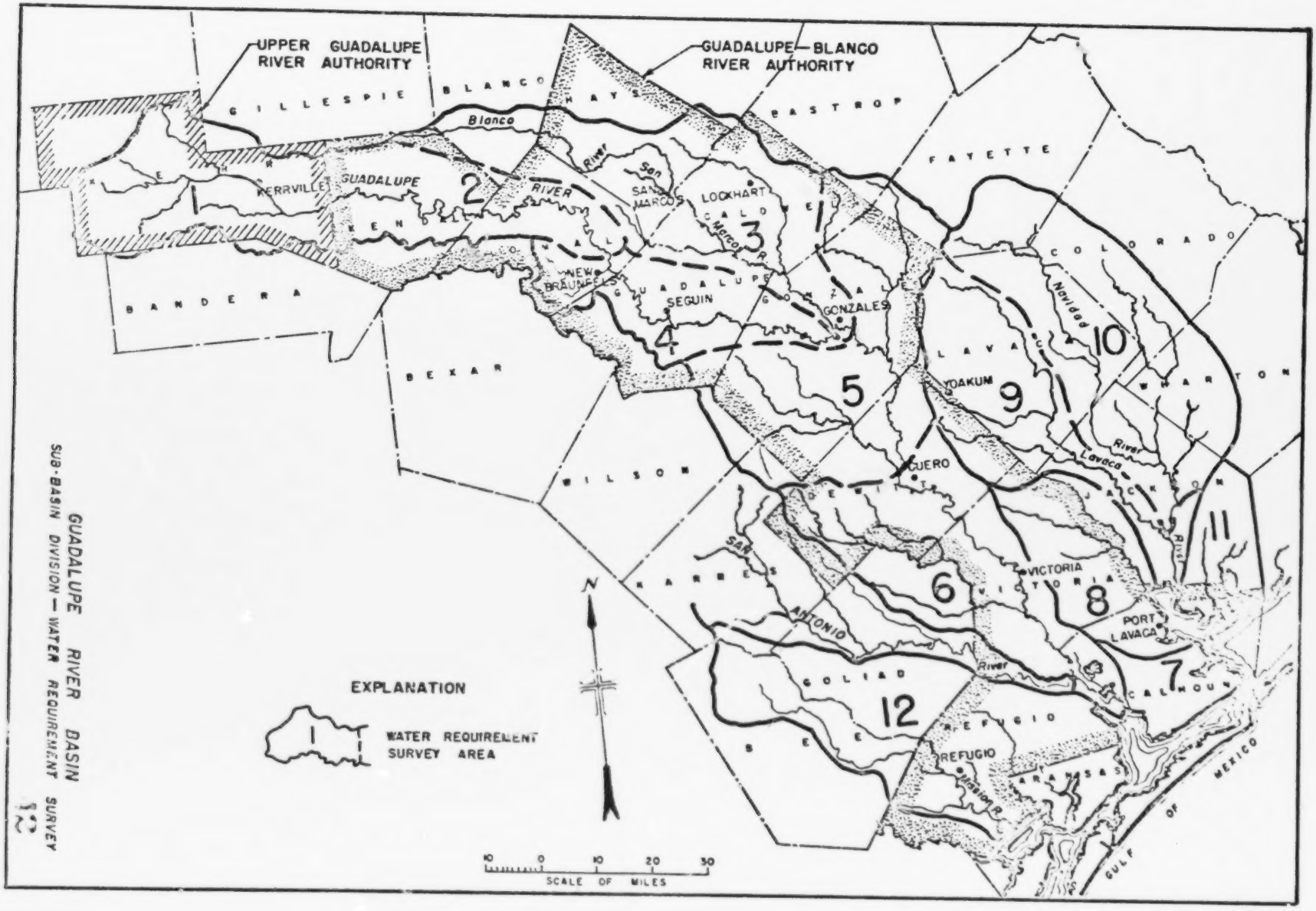

GUADALUPE RIVER BASIN
SUB-BASIN DIVISION — WATER REQUIREMENT SURVEY

TABLE C-2
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
COLORADO RIVER BASIN AND ADJOINING AREAS

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
Area 1										
A										
Brownfield	1,037	728	80	610	100	1,702	1,143	100	810	130
Other	3,917	2,749	100	800	130	4,467	2,999	110	820	140
Subtotal	4,954	3,477	480	20,710	620	6,169	4,142	580	21,860	750
Industrial	2,752	2,043	300	19,300	390	2,818	2,091	370	20,230	480
Nonindustrial	2,202	1,434	180	1,410	230	3,351	2,051	210	1,630	270
B										
Andrews	1,330	823	90	680	110	1,686	1,062	110	830	140
Lamesa	1,159	717	90	680	110	1,955	1,229	120	930	150
Midland	5,220	3,228	370	2,850	470	9,550	6,012	560	4,350	710
Odessa	9,441	5,838	500	3,920	640	19,665	12,377	760	5,920	970
Other	13,452	8,317	290	2,280	370	18,142	11,417	330	2,540	420
Subtotal	30,602	18,923	2,260	26,600	2,890	50,998	32,097	3,310	39,570	4,240
Industrial	13,015	7,984	920	16,190	1,190	20,665	13,230	1,430	25,000	1,850
Nonindustrial	17,587	10,939	1,340	10,410	1,700	30,333	18,867	1,880	14,570	2,390
Total Area 1										
Total	35,556	22,400	2,740	47,310	3,510	57,167	36,239	3,890	61,430	4,990
Industrial	15,767	10,027	1,220	35,490	1,580	23,483	15,321	1,800	45,230	2,330
Nonindustrial	19,789	12,373	1,520	11,820	1,930	33,684	20,918	2,090	16,200	2,660
Area 2										
A										
Snyder	1,758	1,042	80	640	110	2,378	1,379	100	790	130
Other	4,062	2,406	70	510	80	4,689	2,718	40	310	50
Subtotal	5,820	3,448	440	3,390	560	7,067	4,097	480	3,800	620
Industrial	3,942	2,225	290	2,240	370	4,751	2,680	340	2,700	440
Nonindustrial	1,878	1,223	150	1,150	190	2,316	1,417	140	1,100	180
B										
Big Spring	7,044	4,880	160	1,280	210	16,673	11,504	200	1,530	250
Colorado City	1,022	708	60	430	70	1,571	1,084	70	580	100
Other	1,808	1,253	60	470	80	2,243	1,548	30	210	30
Subtotal	9,874	6,841	890	17,080	1,140	20,487	14,136	1,840	34,750	2,340
Industrial	6,135	4,407	610	14,900	790	15,423	11,037	1,540	32,430	1,960
Nonindustrial	3,739	2,434	280	2,180	360	5,064	3,099	300	2,320	380
C										
San Angelo	6,213	3,922	460	3,570	580	10,892	6,881	650	5,070	830
Other	1,485	937	90	700	110	2,042	1,290	80	620	100
Subtotal	7,698	4,859	600	5,200	750	12,934	8,171	810	7,300	1,040
Industrial	583	433	50	930	60	1,013	756	80	1,610	110
Nonindustrial	7,115	4,426	550	4,270	690	11,921	7,415	730	5,690	930

TABLE C-2 (Cont'd)
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
COLORADO RIVER BASIN AND ADJOINING AREAS (Continued)

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
D										
Brownwood	2,132	1,407	120	930	150	2,591	1,632	140	1,130	190
Coleman	526	347	40	290	50	788	496	40	340	60
Other	660	436	30	230	40	809	510	10	110	20
Subtotal	3,318	2,190	230	2,080	280	4,188	2,638	250	2,640	340
Industrial	371	272	40	630	40	627	459	60	1,060	70
Nonindustrial	2,947	1,918	190	1,450	240	3,561	2,179	190	1,580	270
E										
Ballinger	574	386	40	290	50	809	529	40	340	60
Other	847	570	50	400	70	854	558	20	190	30
Subtotal	1,421	956	130	1,210	170	1,663	1,087	120	1,330	170
Industrial	356	263	40	520	50	545	403	60	800	80
Nonindustrial	1,065	693	90	690	120	1,118	684	60	530	90
F										
Brady	903	562	40	340	60	1,501	934	70	560	90
Other	891	554	80	610	100	1,158	720	70	580	90
Subtotal	1,794	1,116	120	950	160	2,659	1,654	140	1,140	180
Industrial	-	-	-	-	-	-	-	-	-	-
Nonindustrial	1,794	1,116	120	950	160	2,659	1,654	140	1,140	180
Total Area 2										
Total	29,925	19,410	2,410	29,910	3,060	48,998	31,783	3,640	50,960	4,690
Industrial	11,387	7,600	1,030	19,220	1,300	22,359	15,335	2,080	38,600	2,660
Nonindustrial	18,538	11,810	1,380	10,690	1,760	26,639	16,448	1,560	12,360	2,030
Area 3										
A										
Subtotal	853	531	80	590	100	1,443	898	90	730	120
Industrial	-	-	-	-	-	-	-	-	-	-
Nonindustrial	853	531	80	590	100	1,443	898	90	730	120
B										
Subtotal	1,051	438	150	1,170	190	1,609	555	100	750	120
Industrial	-	-	-	-	-	-	-	-	-	-
Nonindustrial	1,051	438	150	1,170	190	1,609	555	100	750	120
C										
Subtotal	735	382	60	480	80	1,240	600	80	640	110
Industrial	-	-	-	-	-	-	-	-	-	-
Nonindustrial	735	382	60	480	80	1,240	600	80	640	110

TABLE C-2 (Cont'd)

MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
COLORADO RIVER BASIN AND ADJOINING AREAS (Continued)

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
D										
Austin	23,582	10,073	1,480	11,600	1,900	49,252	17,648	2,840	22,190	3,630
Other	3,500	1,495	310	2,390	390	4,571	1,637	350	2,740	450
Subtotal	27,082	11,568	1,880	18,300	2,400	53,823	19,285	3,370	36,690	4,310
Industrial	838	624	90	4,310	110	1,735	1,315	180	11,760	230
Nonindustrial	26,244	10,944	1,790	13,990	2,290	52,088	17,970	3,190	24,930	4,080
Total Area 3										
Total	29,721	12,919	2,170	20,540	2,770	58,115	21,338	3,640	38,810	4,660
Industrial	838	624	90	4,310	110	1,735	1,315	180	11,760	230
Nonindustrial	28,883	12,295	2,080	16,230	2,660	56,380	20,023	3,460	27,050	4,430
Area 4										
Bay City	1,125	708	90	710	120	3,098	1,979	190	1,460	240
El Campo	418	262	50	360	60	1,132	723	90	730	120
Other	50,495	31,825	330	2,570	420	106,853	68,219	290	2,250	370
Total	52,038	32,795	4,910	40,050	6,460	111,083	70,921	10,310	55,150	13,940
Industrial	48,038	30,063	4,440	36,410	5,860	103,789	66,195	10,240	50,710	13,410
Nonindustrial	4,000	2,732	470	3,640	600	7,294	4,726	570	4,440	730
Total Areas 1, 2, 3 and 4										
Total	147,240	87,524	12,230	137,810	15,800	275,363	160,281	21,980	206,350	28,280
Industrial	76,030	48,314	6,780	95,430	8,850	151,366	98,166	14,300	146,300	18,420
Nonindustrial	71,210	39,210	5,450	42,380	6,950	123,997	62,115	7,680	60,050	9,860

(1) Assumed treatment: 90% reduction of B.O.D. (Biochemical oxygen demand) and organic matter in municipal wastes and an equivalent quality in industrial return flows.
15% reduction of mineral matter.

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GUADALUPE RIVER BASIN

Note: The Guadalupe River Basin was the first to be evaluated for return flows and waste constituents. The detailed summary of each of its subareas has been retained in this report; thus the difference in format from the other study areas, which consider only the subareas with the major loading of waste constituents in return flows.

Area 1

The Guadalupe River originates in this 850 square-mile area at river mile 431, and travels 26 miles before entering Area 2. There is no major water-using industrial activity at present, nor is any anticipated through the year 2010.

Municipal return flows in 1975 are expected to reach 620 MGY (million gallons per year), with an increment (after treatment) of 80 tons of biochemical oxygen demand, 680 tons of minerals, and 110 tons of organic material. By the year 2010, these quantities are expected to reach 1,450 MGY, and 170, 1,290, and 210 tons per year, respectively.

Area 2

The Guadalupe River flows 118 miles through this 670 square-mile drainage area It contains no major cities, and the projected rural population of 3,600 in the year 2010 should have a negligible effect on the river.

Return flows in 1975 are expected to reach 230 MGY, with an increment (after treatment) of 20 tons of biochemical oxygen demand, 130 tons of minerals, and 20 tons of organics. By the year 2010, these quantities are expected to reach 350 MGY and 20, 130, and 20 tons per year, respectively.

Area 2 is the least densely populated area in the Guadalupe Basin. It is expected to remain so in the years 1975 and 2010, with anticipated constant density of 5.4 persons per square mile. Although the return water will increase in volume from 230 MGY in 1975 to 350 MGY in 2010, the constituent loading should remain the same; this may be accounted for by an increased per capita use of water (e.g., automatic washers may use several more times as much water as a manually-operated machine, to remove about the same amount of soil).

Area 3

Although this area contains only five miles of the main stem of the Guadalupe River, it covers about 1,380 square miles of the Blanco and San Marcos River Basins; these rivers combine and discharge an average 300 CFS to the Guadalupe River at river mile 175.

The projected population for this area in the years 1975 and 2010 is 62,300 and 88,900 respectively. Gonzales is the only city in this area that obtains its water from the Guadalupe River. Treatment includes coagulation, sedimentation, rapid sand filtration, and pre and post-chlorination. The other communities obtain their water supplies from ground-water sources.

Municipal and industrial return flows in 1975 are expected to total 2,080 MGY, and have an increment (after treatment) of 330 tons of biochemical oxygen demand, 4,530 tons of minerals, and 420 tons of organics daily. By the year 2010, these quantities are expected to increase to 3,660 MGY, 490 8,270, and 630 tons per year, respectively. The industrial portion of these quantities are based principally on the average characteristics of return waters from processing poultry, jute goods, and cottonseed oil. Oil production is rather prevalent in this area. Mineral estimates for this area have been made with the assumption that all brines resulting from oil production will be reinjected and thus will not reach the streams.

Area 4

The Guadalupe River flows 112 miles through this 595 square-mile drainage area, which is upstream from Area 3. There is no gaging station in this reach.

The cities of Seguin and New Braunfels are in Area 4. Seguin obtains its water supply from the Guadalupe River. Treatment consists of coagulation, sedimentation, rapid sand filtration, chlorination, and taste and odor control. New Braunfels obtains its municipal supply from wells.

Poultry processing and textile weaving, dyeing, and finishing are the principal industries in the area. Oil is also produced in this area.

Municipal and industrial return flows in 1975 are expected to total 3,310 MGY, and have an increment (after treatment) of 380 tons of biochemical oxygen demand, 9,830 tons of minerals, and 480 tons of organics. By the year 2010, these quantities are expected to increase to 6,580 MGY and 670, 16,360 and 860 tons, respectively.

Area 5

The Guadalupe River flows 112 miles through this 1,390 square-mile drainage area. Peach and Sandy Fork Creeks drain the eastern half of the basin, and Sandies Creek drains the western half. There are no major cities in this area. Poultry processing is the principal industry.

Municipal and industrial return flows in 1975 are expected to total 570 MGY, and have an increment (after treatment) of 90 tons of biochemical oxygen demand, 730 tons of minerals, and 120 tons of organics. By the year 2010, these quantities are expected to increase to 760 MGY and 90, 750 and 120 tons, respectively.

Area 6

This area contains the largest industrial complex of the Guadalupe Basin and has a potential for expansion that must be given due consideration in water quality evaluations.

The Guadalupe River flows 105 miles through the 965 square miles of this drainage area, before discharging to the Gulf of Mexico.

The two major cities in Area 6, Cuero and Victoria, both obtain their water supplies from wells. Petroleum production and refining as well as petrochemical production are the principal industrial activities.

Municipal and industrial return flows in 1975 are expected to total 10,280 MGY and have an increment (after treatment) of 1,650 tons of biochemical oxygen demand, 13,430 tons of minerals, and 2,120 tons of organics. By the year 2010, these quantities are expected to increase to 30,500 MGY and 3,330, 37,450, and 5,930 tons, respectively.

Area 7

The 216 square miles of this area drain directly into the Gulf of Mexico. The principal industry produces organic chemicals.

This is the smallest subarea in the Guadalupe and adjoining basins. If the projected populations for 1975 and 2010 are realized, the population density will be 288 and 737 persons per square mile.

Industrial and nonindustrial return flows in 1975 are expected to total 4,670 MGY and have an increment (after treatment) of 990 tons of biochemical oxygen demand, 7,750 tons of minerals and 1,270 tons of organics. By the year 2010, these quantities are expected to increase to 14,700 MGY and 2,960, 23,270 and 3,810 tons, respectively.

Area 8

The 602 square miles of this area drain into the Arenoso Creek, and thence to the Gulf.

The major city is Port Lavaca, which obtains its water supply from wells. The principal industry produces organic chemicals.

Municipal and industrial return flows in 1975 are expected to total 5,910 MGY, and have an increment (after treatment) of 1,060 tons of biochemical oxygen demand, 8,400 tons of minerals, and 1,360 tons of organics. By the year 2010, these quantities are expected to increase to 23,900 MGY and 3,880, 30,790 and 5,000 tons, respectively.

Area 9

The 798 square miles of this area drain into the Lavaca River and thence to the Gulf. Yoakum is the major city, and the principal industries include poultry processing, malt liquor production, vegetable canning, and leather processing.

Municipal and industrial return flows in 1975 are expected to total 970 MGY and have an increment (after treatment) of 150 tons of biochemical oxygen demand, 1,580 tons of minerals and 200 tons of organics. By the year 2010, these quantities are expected to increase to 1,450 MGY and 180, 1,840 and 230 tons, respectively.

Area 10

The 1,548 square miles of this area drain into the Gulf via the Navidad River. Petroleum refining, gas, and poultry processing are the principal industries.

Municipal and industrial return flows in 1975 are expected to total

1030 MGY and have an increment (after treatment) of 180 tons of biochemical oxygen demand, 1,980 tons of minerals and 230 tons of organics. By the year 2010, these quantities are expected to increase to 1,380 MGY and 190, 2,010, and 240 tons, respectively.

Area 11

The 301 square miles in Area 11 drain directly to the Gulf. The principal industry is aluminum ore refining.

Municipal and industrial return flows in 1975 are expected to total 1,090 MGY and have an increment (after treatment) of 30 tons of biochemical oxygen demand, 220 tons of minerals and 40 tons of organics. By the year 2010, these quantities are expected to increase to 4,520 MGY and 60, 460 and 70 tons, respectively.

Area 12

The 1,548 square miles in this area drain to the Mission River and thence to the Gulf. Principal industries are petroleum and gas.

Municipal and industrial return flows in 1975 are expected to total 1,210 MGY and have an increment (after treatment) of 220 tons of biochemical oxygen demand, 1,730 tons of minerals and 280 tons of organics. By the year 2010, these quantities are expected to increase to 1,760 MGY and 300, 2,340 and 380 tons, respectively.

The above mineral concentrations are far less than are currently found in the area. It is assumed that oil field brines that are now being discharged to the river will be disposed of by injection in the near future.

TABLE G-1
AREA AND POPULATION DATA
GUADALUPE RIVER BASIN AND ADJOINING AREAS

Area	River Reach (mi.)	Riv Miles	Area (sq. mi.)	Population 1975	Population 2010	Population Density (per sq. mi.) 1975	Population Density (per sq. mi.) 2010
1	431-405	26	850	19,000	36,200	22.4	42.6
2	405-287	118	670	3,600	3,600	5.37	5.37
3	175-170	127 (1)	1,380	62,300	88,900	45.1	64.4
4	287-175	112	595	48,000	73,900	80.7	124
5	170-105	65	1,390	16,200	16,200	11.7	11.7
6	105-0.0	105	965	101,200	174,700	105	181
Adjoining Areas (2)							
7	-	-	216	62,300	159,000	288	737
8	-	-	602	79,300	218,600	134	364
9	-	-	798	25,000	30,600	31.4	39.6
10	-	-	1,548	30,000	32,100	19.4	20.8
11	-	-	301	6,200	12,900	20.4	42.9
12	-	-	1,548	17,800	21,900	11.5	14.1
			10,863	470,900	868,600		

(1) Area 3 has only five miles of Guadalupe River but includes all of Blanco and San Marcos River Basins.

(2) River miles for adjoining areas are not available at this time.
Area 7- Return flow to tidal water
Area 8- Return flow to Arenoso Creek
Area 9- Return flow to Lavaca River
Area 10- Return flow to Navidad River
Area 11- Return flow to tidal water
Area 12- Return flow to Mission River

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TABLE C-2
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
GUADALUPE RIVER BASIN AND ADJOINING AREAS

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
Area 1										
Kerrville	880	550	60	500	80	2,170	1,350	140	1,050	170
Other	110	70	20	180	30	160	100	30	240	40
Total	990	620	80	680	110	2,330	1,450	170	1,290	210
Industrial	-	-	-	-	-	-	-	-	-	-
Nonindustrial	990	620	80	680	110	2,330	1,450	170	1,290	210
Area 2										
Total	360	230	20	130	20	560	350	20	130	20
Industrial	-	-	-	-	-	-	-	-	-	-
Nonindustrial	360	230	20	130	20	560	350	20	130	20
Area 3										
San Marcos	1,200	670	90	680	110	2,730	1,430	160	1,270	210
Lockhart	550	300	40	310	50	1,080	570	60	500	80
Gonzales	540	300	40	320	50	990	520	60	470	80
Other	1,470	810	120	910	150	2,180	1,140	120	930	150
Total	3,760	2,080	330	4,530	420	6,980	3,660	490	8,270	630
Industrial	340	300	40	2,300	50	700	620	80	5,090	110
Nonindustrial	3,420	1,780	290	2,230	370	6,280	3,040	410	3,180	520
Area 4										
New Braunfels	3,460	2,380	110	830	140	7,280	4,960	190	1,500	240
Seguin	1,150	800	70	530	90	2,310	1,570	100	790	130
Other	200	130	50	350	60	70	50	50	350	60
Total	4,810	3,310	380	9,830	480	9,660	6,580	670	16,360	860
Industrial	1,950	1,530	160	8,120	200	3,310	2,640	330	13,720	430
Nonindustrial	2,860	1,780	220	1,710	280	6,350	3,940	340	2,640	430
Area 5										
Total	910	570	90	730	120	1,220	760	90	750	120
Industrial	120	110	20	150	20	140	130	20	170	30
Nonindustrial	790	460	70	580	100	1,080	630	70	580	90
Area 6										
Cuero	1,210	750	50	370	60	2,280	1,410	60	450	70
Victoria	3,750	2,310	340	2,650	430	9,750	6,030	680	5,340	880
Other	11,740	7,220	70	590	100	37,260	23,030	60	450	70
Total	16,700	10,280	1,650	13,430	2,120	49,290	30,470	3,330	37,450	5,930
Industrial	11,600	7,670	1,190	9,820	1,530	37,850	24,600	2,530	31,210	4,910
Nonindustrial	5,100	2,610	460	3,610	590	11,440	5,870	800	6,240	1,020

TABLE C-2 (Cont'd)
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
GUADALUPE RIVER BASIN AND ADJOINING AREAS (Continued)

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
Area 7										
Total	7,360	4,670	990	7,750	1,270	23,160	14,720	2,960	23,270	3,810
Industrial	7,000	4,530	700	5,520	910	22,400	14,400	2,230	17,590	2,880
Nonindustrial	360	140	290	2,230	360	760	320	730	5,680	930
Area 8										
Port Lavaca	8,600	4,840	320	2,500	410	38,930	22,080	900	7,040	1,150
Other	1,890	1,070	40	330	50	3,270	1,850	100	750	130
Total	10,490	5,910	1,060	8,400	1,360	42,200	23,930	3,880	30,790	5,000
Industrial	6,950	4,490	700	5,570	900	28,850	18,600	2,880	23,000	3,720
Nonindustrial	3,540	1,420	360	2,830	460	13,350	5,330	1,000	7,790	1,280
Area 9										
Yoakum	680	410	40	320	50	1,300	740	70	570	90
Other	950	560	70	570	100	1,240	710	70	570	90
Total	1,630	970	150	1,580	200	2,540	1,450	180	1,840	230
Industrial	420	350	40	690	50	450	380	40	750	50
Nonindustrial	1,210	620	110	890	150	2,090	1,070	140	1,090	180
Area 10										
Total	1,730	1,030	180	1,980	230	2,380	1,380	190	2,010	240
Industrial	390	270	40	910	50	360	260	40	870	50
Nonindustrial	1,340	760	140	1,070	180	2,020	1,120	150	1,140	190
Area 11										
Total	4,530	1,090	30	220	40	18,900	4,520	60	460	70
Industrial	4,270	990	-	-	-	18,100	4,200	-	-	-
Nonindustrial	260	100	30	220	40	800	320	60	460	70
Area 12										
Total	2,280	1,210	220	1,730	280	3,420	1,760	300	2,340	380
Industrial	1,330	910	140	1,090	180	1,890	1,280	200	1,560	250
Nonindustrial	950	300	80	640	100	1,530	480	100	780	130
All Areas										
Total	55,550	31,970	5,180	50,990	6,650	162,640	91,030	12,340	124,960	17,500
Industrial	34,370	21,150	3,030	34,170	3,890	114,050	67,110	8,350	93,960	12,420
Nonindustrial	21,180	10,820	2,150	16,820	2,760	48,590	23,920	3,990	31,000	5,070

(1) Assumed treatment: 90% reduction of B.O.D. (Biochemical oxygen demand) and organic matter in municipal wastes and an equivalent quality in industrial return flows.
15% reduction of mineral matter.

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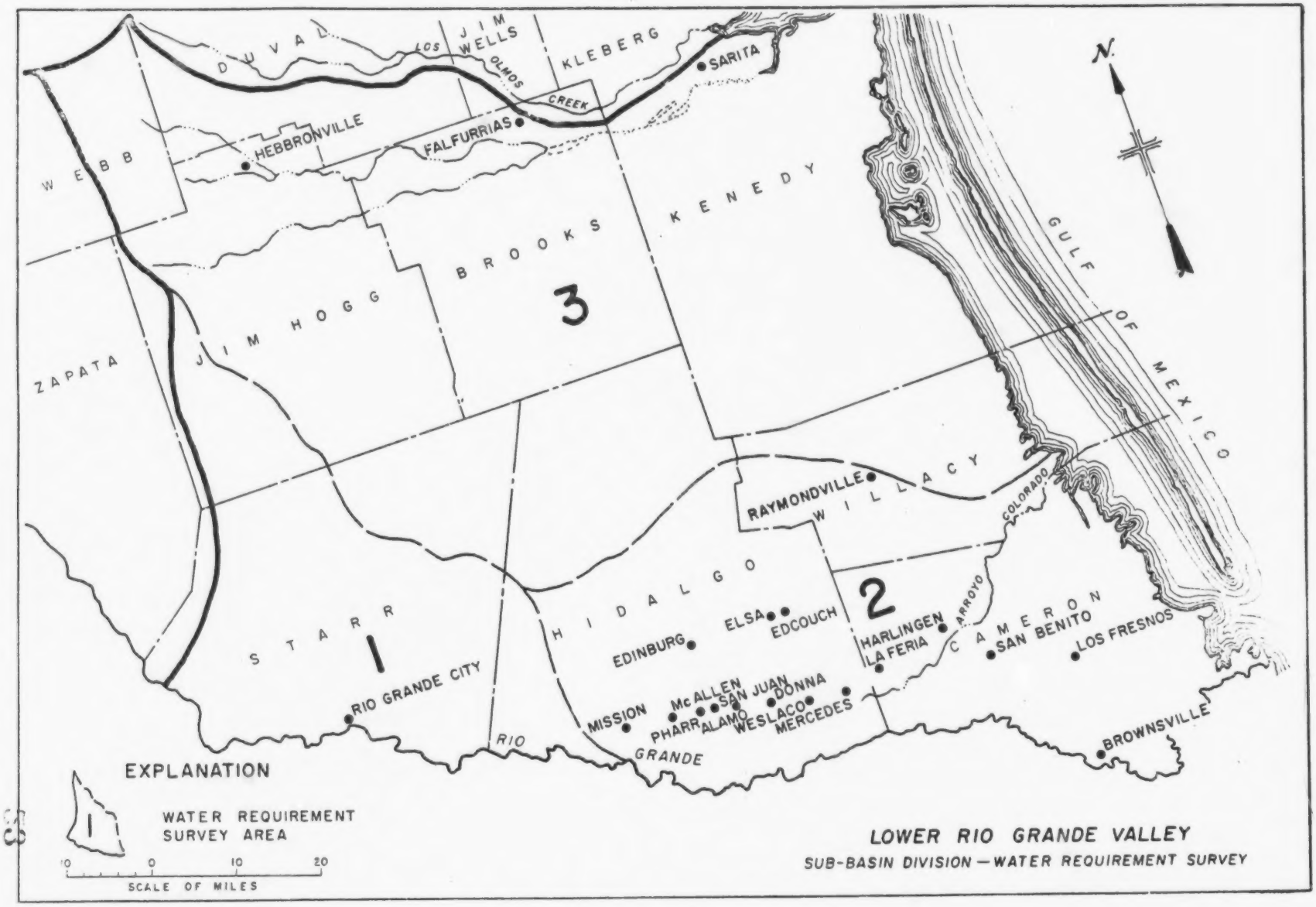
DUVAL
LOS OLMOS CREEK
JIM WELLS
KLEBERG
SARITA
HEBBRONVILLE
FALFURRIAS
WEBB
KENEDY
BROOKS
3
JIM HOGG
ZAPATA
GULF OF MEXICO
N.
RAYMONDVILLE
WILLACY
COLORADO
HIDALGO
2
EDINBURG
ELSA
EDCOUCH
HARLINGEN
LA FERIA
ARROYO
CAMERON
SAN BENITO
LOS FRESNOS
STARR
1
RIO GRANDE CITY
MISSION
McALLEN
PHARR
SAN JUAN
ALAMO
DONNA
WESLACO
MERCEDES
BROWNSVILLE
RIO GRANDE
EXPLANATION
1
WATER REQUIREMENT SURVEY AREA
10 0 10 20
SCALE OF MILES
LOWER RIO GRANDE VALLEY
SUB-BASIN DIVISION — WATER REQUIREMENT SURVEY

LOWER RIO GRANDE VALLEY

Entire Valley

The Lower Rio Grande Valley covers 7,920 square miles. Areas 1 and 2 are on the Rio Grande, and Area 3 is a noncontributing area of drainage to the Rio Grande. The total population is expected to be 559,200 by the year 1975 and 858,000 by the year 2010. Corresponding water requirements for combined municipal andindustrial use are expected to increase to 60,034 million gallons per year (MGY) and 150,377 MGY, respectively.

Return flows will total approximately 33,573 MGY in 1975 and 89,922 MGY in 2010. In 1975, after treatment, the return water will have an incremental constituent load of 2,540 tons of biochemical oxygen demand, 19,960 tons of minerals and 3,280 tons of organics. By 2010, the treated incremental load will include 3,940 tons of biochemical oxygen demand, 30,620 tons of minerals, and 5,020 tons of organics.

Using minerals as an indicator of the major source of quality-related constituents, about 92-95 per cent originates in Area 2.

Area 2 - Nonindustrial

This area includes the cities of Brownsville, Donna, Edinburg, Harlingen, McAllen, Mercedes, Mission, Pharr, Raymondville, San Benito, and Weslaco.

In 1975, a treated nonindustrial return flow of 9,943 MGY will have an incremental constituent load of 2,310 tons of biochemical oxygen demand, 18,090 tons of minerals and 2,980 tons of organics. By the year 2010, the incremental constituent load will include 3,610 tons of biochemical oxygen demand, 28,150 tons of minerals and 4,610 tons of organics in 20,613 MGY return flow.

Area 2 - Industrial

Existing and/or future industrial activities include food processing, primary metal products, organic chemicals, petroleum refining, and stone, clay and glass manufacturing.

In the year 1975, treated industrial return flows are expected to total 17,645 MGY with an incremental constituent loading of 2,550 tons of biochemical oxygen demand, 123,460 tons of minerals, and 3,290 tons of organics. By the year 2010, the treated industrial return flow is expected to total 56,366 MGY with an incremental constituent loading of 8,160 tons of biochemical oxygen demand, 394,960 tons of minerals and 10,520 tons of organics.

TABLE LV-1
AREA AND POPULATION DATA
LOWER RIO GRANDE VALLEY

Area	River Reach (mi.)	River Miles	Area (sq. mi.)	Population 1975	Population 2010	Population Density (per sq. mi.) 1975	Population Density (per sq. mi.) 2010
1	-	-	1,206	32,300	44,800	26.78	37.15
2	-	-	1,777	507,000	788,400	285.31	443.67
3	-	-	4,936	19,900	24,800	4.03	5.02
			7,919	559,200	858,000		

Note:

Area 1 and Area 2 are on the Rio Grande.

Area 3 is a non-contributing area of drainage to the Rio Grande.

River reach and river mile are not available at this time.

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MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
LOWER RIO GRANDE VALLEY

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
Area 1										
Rio Grande City	547	220	40	340	60	1,251	468	80	600	100
Other	1,391	561	100	820	130	2,020	755	130	990	160
Total	1,938	781	160	2,350	220	3,271	1,223	230	2,360	280
Industrial	188	158	20	1,190	30	121	102	20	770	20
Nonindustrial	1,750	623	140	1,160	190	3,150	1,121	210	1,590	260
Area 2										
Brownsville	4,068	2,214	310	2,390	390	8,425	4,962	490	3,790	620
Donna	1,319	718	70	540	90	2,867	1,689	100	790	130
Edinburg	1,226	667	100	800	130	2,328	1,371	140	1,130	180
Harlingen	3,268	1,779	240	1,860	300	8,612	5,072	480	3,790	620
McAllen	2,793	1,520	200	1,560	260	7,000	4,123	410	3,190	520
Mercedes	933	508	80	600	100	1,711	1,008	100	810	130
Mission	1,468	799	110	890	150	3,127	1,842	180	1,390	230
Pharr	905	493	70	580	100	1,630	960	100	770	130
Raymondville	937	510	70	580	100	2,119	1,248	130	980	160
San Benito	1,286	700	110	840	140	2,382	1,403	150	1,140	190
Weslaco	968	527	70	580	100	1,956	1,152	110	850	140
Other	31,508	17,153	880	6,870	1,120	88,538	52,149	1,220	9,520	1,560
Total	50,679	27,588	4,860	141,550	6,270	130,695	76,979	11,770	423,110	15,130
Industrial	22,748	17,645	2,550	123,460	3,290	72,793	56,366	8,160	394,960	10,520
Nonindustrial	27,931	9,943	2,310	18,090	2,980	57,902	20,613	3,610	28,150	4,610
Area 3										
Falfurrias	1,351	948	50	390	60	1,747	1,248	170	530	90
Other	6,066	4,256	40	320	50	14,664	10,472	50	350	60
Total	7,417	5,204	790	9,240	1,020	16,411	11,720	1,740	20,530	2,240
Industrial	6,353	4,825	700	8,530	910	14,657	11,096	1,620	19,650	2,090
Nonindustrial	1,064	379	90	710	110	1,754	624	120	880	150
All Areas										
Total	60,034	33,573	5,810	153,140	7,510	150,377	89,922	13,740	446,000	17,630
Industrial	29,289	22,628	3,270	133,180	4,230	87,571	67,564	9,800	415,380	12,630
Nonindustrial	30,745	10,945	2,540	19,960	3,280	62,806	22,358	3,940	30,620	5,020

(1) Assumed treatment: 90% reduction of B.O.D. (Biochemical oxygen demand) and organic matter in municipal wastes and an equivalent quality in industrial return flows.
15% reduction of mineral matter.

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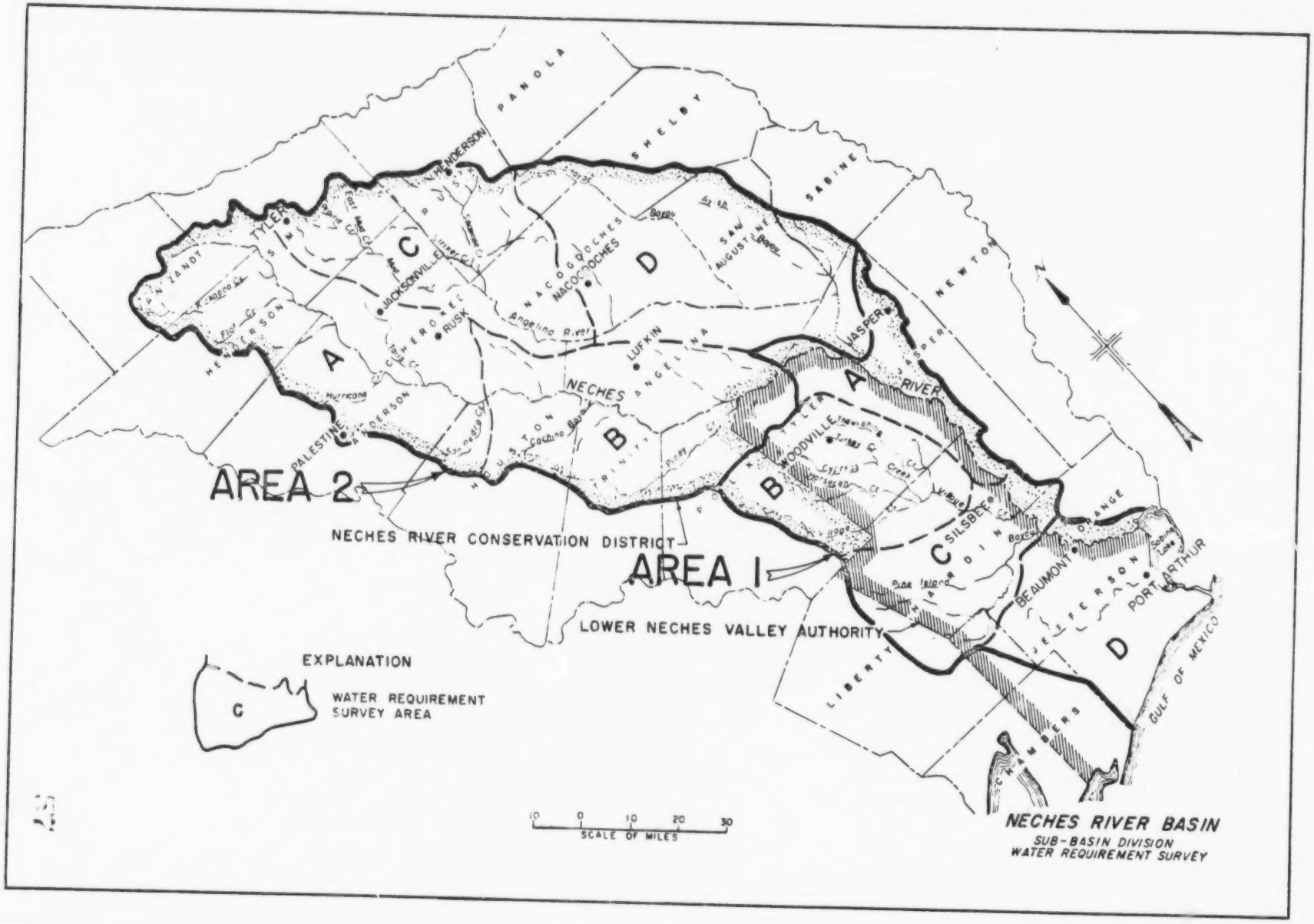
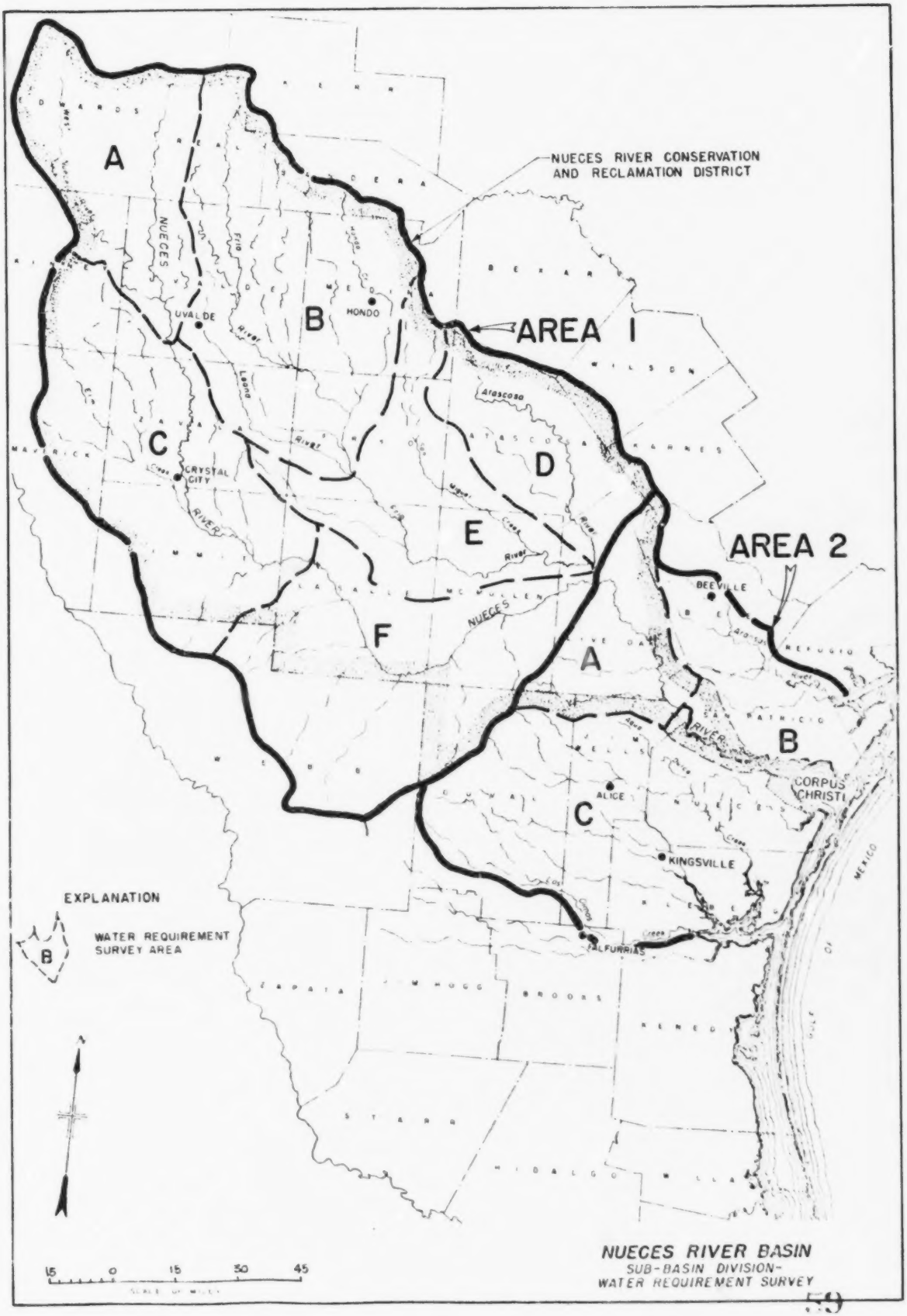

AREA 2
NECHES RIVER CONSERVATION DISTRICT
AREA 1
LOWER NECHES VALLEY AUTHORITY
EXPLANATION
C
WATER REQUIREMENT SURVEY AREA
SCALE OF MILES
10 0 10 20 30
NECHES RIVER BASIN
SUB-BASIN DIVISION
WATER REQUIREMENT SURVEY
PANOLA
SHELBY
SABINE
NEWTON
JASPER
TYLER
HENDERSON
VAN ZANDT
JACKSONVILLE
CHEROKEE
RUSK
NACOGDOCHES
LUFKIN
ANGELINA
NECHES
TRINITY
HOUSTON
PALESTINE
ANDERSON
WOODVILLE
SILSBEE
ORANGE
BEAUMONT
PORT ARTHUR
JEFFERSON
LIBERTY
CHAMBERS
GULF OF MEXICO
A
B
C
D

NECHES RIVER BASIN

Evaluation of the return flows and incremental waste constituents will be added at a later date.


NUECES RIVER CONSERVATION AND RECLAMATION DISTRICT
AREA 1
AREA 2
A
B
C
D
E
F
UVALDE
HONDO
CRYSTAL CITY
BEEVILLE
ALICE
KINGSVILLE
CORPUS CHRISTI
NUECES
RIVER
EXPLANATION
WATER REQUIREMENT SURVEY AREA
NUECES RIVER BASIN
SUB-BASIN DIVISION-
WATER REQUIREMENT SURVEY

NUECES RIVER BASIN

Entire Basin

The Nueces River is about 450 miles long and drains an area covering 16,900 square miles. The total population is expected to be 844,200 by the year 1975 and 1,572,700 by the year 2010. Corresponding water requirements for combined municipal and industrial use are expected to increase to 85,640 million gallons per year (MGY) and 185,570 MGY, respectively. Return flows will be approximately 36,430 MGY in 1975 and 70,300 MGY in 2010. In 1975, after treatment, the return water will have an incremental constituent load of 5,840 tons of biochemical oxygen demand, 64,480 tons of minerals and 7,470 tons of organics. In 2010, the incremental load will include 11,450 tons of biochemical oxygen demand, 128,400 tons of minerals, and 14,690 tons of organics.

Using minerals as an indicator of the major source of quality-related constituents, about 80 per cent originates in Area 2C.

Area 2C - Nonindustrial

This 3,907 square mile area drains into the Nueces River from river mile 46 to the mouth. It includes the cities of Alice, Corpus Christi and Kingsville. In 1975, about 8,160 MGY of nonindustrial return water will be incremented by a 2,960 tons of biochemical oxygen demand, 23,110 tons of minerals and 3,790 tons of organics. By the year 2010, the nonindustrial return water may increase to 15,330 MGY, with an incremental load of 6,020 tons of biochemical oxygen demand, 47,030 tons of minerals and 7,690 tons of organics.

Area 2C - Industrial

The dominant industrial growth is expected to be in manufacturing transportation equipment, chemicals and allied products, machinery including electrical machinery and equipment, and fabricated metal products. Existing industrial activities include refining, chemicals and primary metals. In the year 1975, industrial return flows are expected to total 16,080 MGY, with an incremental constituent loading of 1,780 tons of biochemical oxygen demand, 27,760 tons of minerals, and 2,300 tons of organics. By the year 2010, the industrial return flow is expected to total 35,740 MGY, with an incremental constituent loading of 3,910 tons of biochemical oxygen demand, 60,590 tons of minerals and 5,040 tons of organics.

TABLE NU-1
AREA AND POPULATION DATA
NUECES RIVER BASIN AND ADJOINING AREAS

Area	River Reach (mi.)	River Miles	Area (sq. mi.)	Population 1975	Population 2010	Population Density (per sq. mi.) 1975	Population Density (per sq. mi.) 2010
1-A	362-446	84	1,947	4,000	4,700	2.05	2.41
B (1)	124-266	142	3,493	48,900	78,000	14.00	22.33
C	240-362	122	3,313	32,300	51,000	9.75	15.67
D (2)	0- 98	98	1,423	24,100	29,700	16.94	20.87
E (3)	6-124	118	2,095	12,100	14,100	5.78	6.73
F (4)	104-240	136	3,329	11,200	12,500	3.36	3.75
2-A	46-104	58	1,060	25,600	27,700	24.15	26.13
B (5)	0- 46	46	1,256	37,700	36,400	30.02	28.98
C	0- 46	46	3,907	648,300	1,318,600	165.93	337.50
			21,823	844,200	1,572,700		

(1) River reach and river mile are for the Frio River and are to the headwaters.

(2) River reach and river mile are for the entire basin of the Atasosa River.

(3) River reach and river mile are for the Frio River, the sub-basins are starting at the mouth of the Atascosa River at mile 6 of the Frio River.

(4) This sub-basin also contains 6 miles of the Frio River.

(5) The Nueces River is the dividing line between sub-basins 2-B and 2-C.

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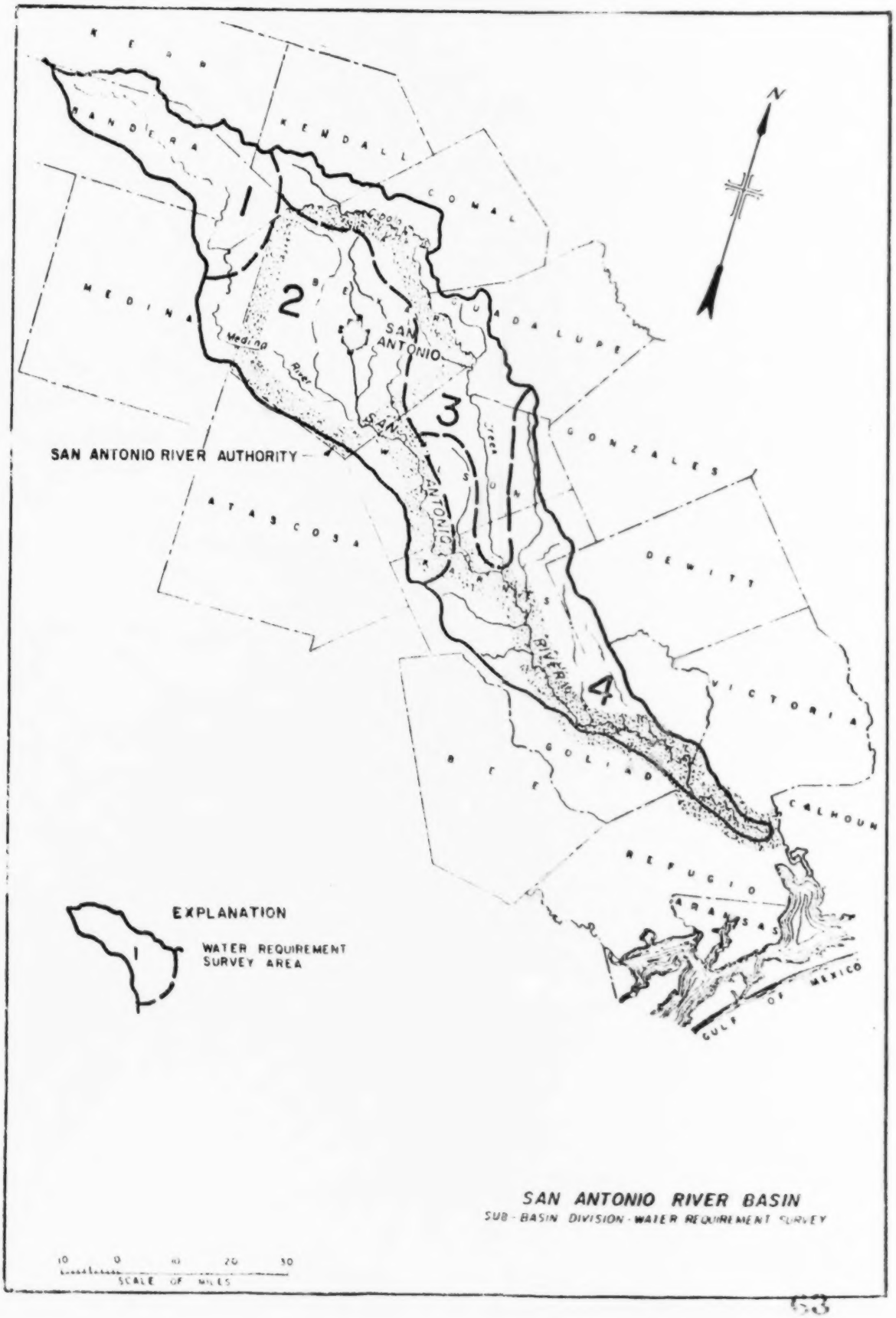
TABLE NU-2
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
NUECES RIVER BASIN AND ADJOINING AREAS

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
Area 1										
A										
Subtotal	220	140	20	140	20	330	210	20	170	30
Industrial	-	-	-	-	-	-	-	-	-	-
Nonindustrial	220	140	20	140	20	330	210	20	170	30
B										
Hondo	520	320	40	300	50	1,000	620	60	480	80
Uvalde	1,300	810	60	500	80	2,080	1,300	100	800	130
Other	1,480	920	120	940	150	2,800	1,740	190	1,500	250
Subtotal	3,300	2,050	220	1,740	280	5,880	3,660	350	2,780	460
Industrial	-	-	-	-	-	-	-	-	-	-
Nonindustrial	3,300	2,050	220	1,740	280	5,880	3,660	350	2,780	460
C										
Crystal City	840	550	50	430	70	1,940	1,260	100	780	130
Other	1,140	740	90	720	120	2,070	1,350	140	1,070	170
Subtotal	1,980	1,290	170	2,900	220	4,010	2,610	290	5,300	360
Industrial	170	160	30	1,750	30	340	330	50	3,450	60
Nonindustrial	1,810	1,130	140	1,150	190	3,670	2,280	240	1,850	300
D										
Subtotal	1,550	1,080	160	2,920	180	2,210	1,470	170	2,920	230
Industrial	320	310	50	2,060	40	290	280	40	1,860	60
Nonindustrial	1,230	770	110	860	140	1,920	1,190	130	1,060	170
E										
Subtotal	790	530	70	1,220	90	1,080	700	80	1,180	100
Industrial	120	110	20	790	20	110	100	20	680	20
Nonindustrial	670	420	50	430	70	970	600	60	500	80
F										
Subtotal	800	560	80	1,550	100	1,060	720	80	1,620	110
Industrial	180	170	30	1,150	30	190	180	30	1,180	40
Nonindustrial	620	390	50	400	70	870	540	50	440	70
Total Area 1										
Total	8,640	5,650	720	10,470	890	14,570	9,370	990	13,970	1,290
Industrial	790	750	130	5,750	120	930	890	140	7,170	180
Nonindustrial	7,850	4,900	590	4,720	770	13,640	8,480	850	6,800	1,110



SAN ANTONIO RIVER BASIN

SUB-BASIN DIVISION-WATER REQUIREMENT SURVEY

TABLE NU-2 (Cont'd)
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
NUECES RIVER BASIN AND ADJOINING AREAS (Continued)

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
Area 2										
A										
Subtotal	1,480	930	130	1,050	170	2,160	1,350	150	1,180	190
Industrial	160	110	20	140	20	240	160	20	190	30
Nonindustrial	1,320	820	110	910	150	1,920	1,190	130	990	160
B										
Beeville	1,030	400	80	610	100	1,530	530	90	700	110
Other	13,320	5,210	90	740	120	43,870	15,130	80	590	100
Subtotal	14,350	5,610	250	2,090	320	45,400	15,660	380	5,620	480
Industrial	5,450	3,550	80	740	100	11,860	7,980	210	4,330	270
Nonindustrial	8,900	2,060	170	1,350	220	33,540	7,680	170	1,290	210
C										
Alice	1,860	740	130	1,060	170	2,980	1,230	180	1,420	230
Corpus Christi	55,040	21,810	2,560	19,960	3,270	116,540	48,220	5,510	43,070	7,040
Kingsville	2,560	1,010	140	1,080	180	3,730	1,540	190	1,460	240
Other	1,710	680	130	1,010	170	190	80	140	1,080	180
Subtotal	61,170	24,240	4,740	50,870	6,090	123,440	51,070	9,930	107,620	12,730
Industrial	25,990	16,080	1,780	27,760	2,300	56,500	35,740	3,910	60,590	5,040
Nonindustrial	35,180	8,160	2,960	23,110	3,790	66,940	15,330	6,020	47,030	7,690
Total Area 2										
Total	77,000	30,780	5,120	54,010	6,580	171,000	60,930	10,460	114,420	13,400
Industrial	31,600	19,740	1,880	28,640	2,420	68,600	43,880	4,140	65,110	5,340
Nonindustrial	45,400	11,040	3,240	25,370	4,160	102,400	17,050	6,320	49,310	8,060
Total Areas 1 and 2										
Total	85,640	36,430	5,840	64,480	7,470	185,570	70,300	11,450	128,390	14,690
Industrial	32,390	20,490	2,010	34,390	2,540	69,530	44,770	4,280	72,280	5,520
Nonindustrial	53,250	15,940	3,830	30,090	4,930	116,040	25,530	7,170	56,110	9,170

(1) Assumed treatment: 90% reduction of B.O.D. (Biochemical oxygen demand) and organic matter in municipal wastes and an equivalent quality in industrial return flows.
15% reduction of mineral matter.

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SAN ANTONIO RIVER BASIN

Municipal Return Water - 1975

In the year 1975, the population of the San Antonio River Basin is expected to be 1,034,700. The corresponding nonindustrial water requirement will be 63,050 million gallons per year (MGY), with a subsequent return flow of 39,230 MGY. Quality-related constituents in this return flow will be incremented by approximately 4,730 tons of biochemical oxygen demand, 36,900 tons of minerals and 6,060 tons of organics.

Municipal Return Water - 2010

The population is expected to increase to 2,070,000 by the year 2010, with a corresponding nonindustrial water requirement of 154,700 MGY. The subsequent return flow will be 96,190 MGY, incremented by approximately 9,500 tons of biochemical oxygen demand, 72,800 tons of minerals and 12,100 tons of organics.

Industrial Return Water - 1975

Industrial water requirements in the San Antonio River Basin are expected to increase to 11,980 MGY by the year 1975, with a subsequent return flow of 9,830 MGY. Waste products may be expected to increase the constituent load by 6,960 tons of biochemical oxygen demand, 193,800 tons of minerals and 8,990 tons of organics.

Industrial Return Water - 2010

The total industrial water requirement is expected to increase to 27,210 MGY by the year 2010, with a return flow of 19,860 MGY.

Quality-related constituents in the return flow will be incremented by approximately 2,560 tons of biochemical oxygen demand, 72,200 tons of minerals and 3,300 tons of organics.

Location of Major Source of Wastes

Of the total return flow constituents shown above for the San Antonio River Basin, 95 to 99 per cent will originate in Area 2.

Area 2 covers 1,450 square miles and includes the city of San Antonio. The area drains into the Medina River, Olmos Creek and 93 miles of the San Antonio River from river miles 144-237. The population of this area is expected to reach 982,000 by the year 1975 and 2,015,500 by the year 2010. Principal industries will include textiles and apparel, transportation equipment manufacturing, and food and kindred products.

TABLE SA-1
AREA AND POPULATION DATA
SAN ANTONIO RIVER BASIN

Area	River Reach (mi.)	River Miles	Area (sq. mi.)	Population 1975	Population 2010	Population Density (per sq. mi.) 1975	Population Density (per sq. mi.) 2010
1 (1)	-	-	623	5,400	5,500	8.67	8.83
2 (2)	144-237	93	1,448	982,000	2,015,500	678.17	1391.92
3 (1)	-	-	831	23,800	27,300	28.64	32.85
4	0-144	144	1,315	23,500	21,700	17.87	16.50
			4,217	1,034,700	2,070,000		

(1) River reach and river miles are not available at this time.

Area 1 - Return flow to Medi River
Area 3 - Return flow to Cibolo Creek

(2) Area 2 includes 74 miles of the Medi River and all of Olmos Creek.

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TABLE SA-2
MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
SAN ANTONIO RIVER BASIN

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
Area 1										
Total	300	190	30	190	30	390	240	30	200	30
Industrial	-	-	-	-	-	-	-	-	-	-
Nonindustrial	300	190	30	190	30	390	240	30	200	30
Area 2										
San Antonio	70,970	46,470	4,340	33,960	5,570	173,530	112,600	9,050	70,820	11,590
Other	1,290	840	140	1,070	180	1,470	1,000	140	1,080	180
Total	72,260	47,310	5,730	70,180	7,360	175,000	113,600	11,720	143,130	15,030
Industrial	11,820	9,710	1,250	35,150	1,610	24,030	19,700	2,530	71,230	3,260
Nonindustrial	60,440	37,600	4,480	35,030	5,750	150,970	93,900	9,190	71,900	11,770
Area 3										
Total	1,240	790	120	900	150	1,900	1,200	130	1,030	170
Industrial	60	50	10	50	10	60	60	10	60	10
Nonindustrial	1,180	740	110	850	140	1,840	1,140	120	970	160
Area 4										
Total	1,230	770	120	1,010	160	1,580	990	120	970	150
Industrial	100	70	10	170	20	120	80	20	200	20
Nonindustrial	1,130	700	110	840	140	1,460	910	100	770	130
All Areas										
Total	75,030	49,060	6,000	72,280	7,700	178,870	116,030	12,000	145,330	15,380
Industrial	11,980	9,830	1,270	35,370	1,640	24,210	19,840	2,560	71,490	3,290
Nonindustrial	63,050	39,230	4,730	36,910	6,060	154,660	96,190	9,440	73,840	12,090

(1) Assumed treatment: 90% reduction of B.O.D. (Biochemical oxygen demand) and organic matter in municipal wastes and an equivalent quality in industrial return flows.
15% reduction of mineral matter.

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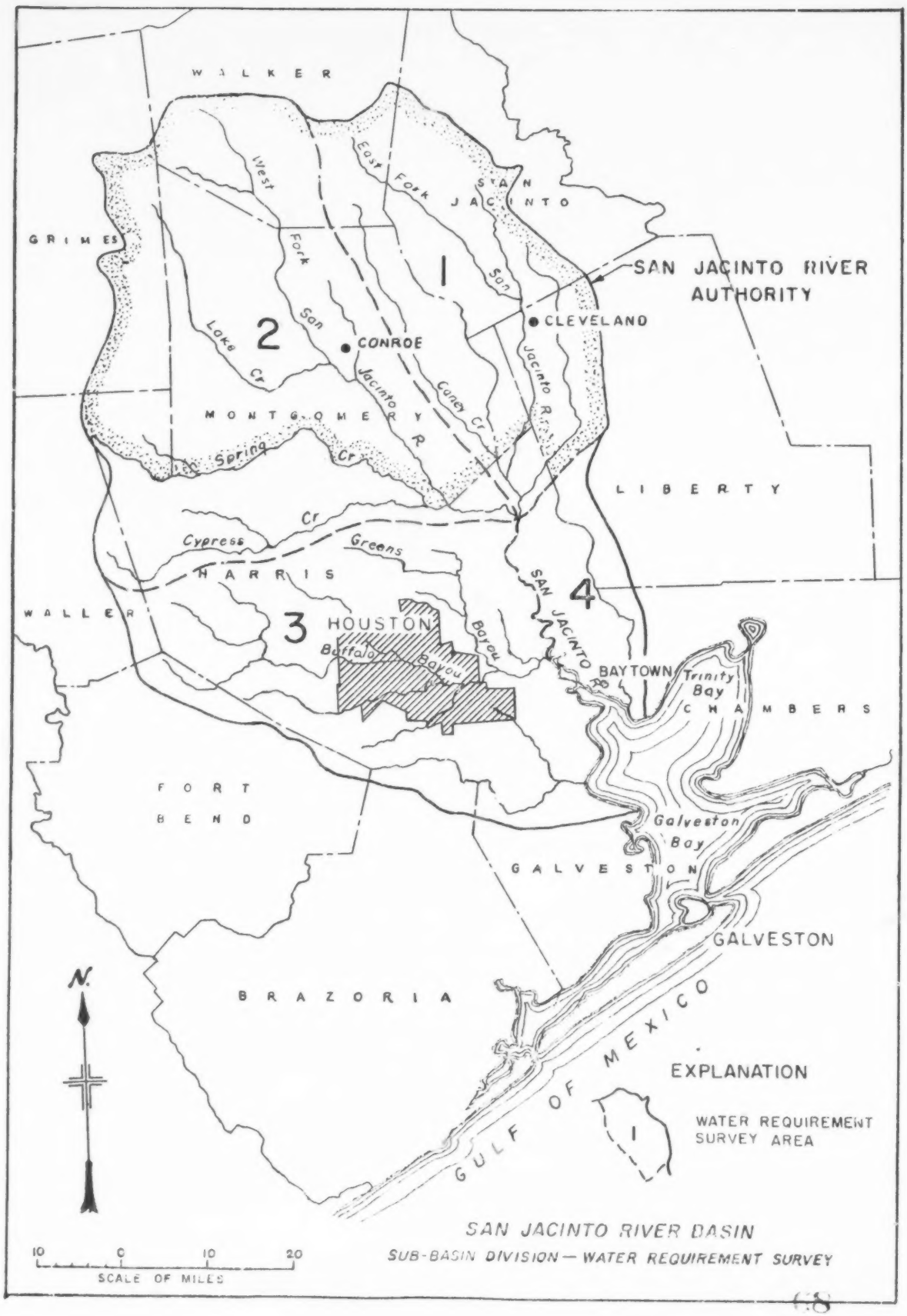
WALKER
GRIMES
MONTGOMERY
HARRIS
WALLER
FORT BEND
BRAZORIA
LIBERTY
CHAMBERS
GALVESTON
West Fork San Jacinto
East Fork San Jacinto
San Jacinto River
Lake Cr
Spring Cr
Cypress Cr
Greens Bayou
Buffalo Bayou
Caney Cr
Jacinto R.
San Jacinto R.
CONROE
CLEVELAND
HOUSTON
BAYTOWN
Trinity Bay
Galveston Bay
GALVESTON
GULF OF MEXICO
1
2
3
4
SAN JACINTO RIVER AUTHORITY
N.
EXPLANATION
WATER REQUIREMENT SURVEY AREA
10 0 10 20
SCALE OF MILES
SAN JACINTO RIVER BASIN
SUB-BASIN DIVISION — WATER REQUIREMENT SURVEY

SAN JACINTO RIVER BASIN

Entire Basin

The San Jacinto River is only 28 miles long and drains an area of 4,525 square miles. The total population is expected to be 1,537,000 by the year 1975 and 3,202,700 by the year 2010. Corresponding water requirements for combined municipal and industrial use are expected to increase to 226,092 million gallons per year (MGY) and 657,130 MGY, respectively.

Return flows will total approximately 143,624 MGY in 1975 and 396,593 MGY in 2010. In 1975, after treatment, the return water will have an incremental constituent load of 19,610 tons of biochemical oxygen demand, 182,590 tons of minerals and 25,200 tons of organics. By 2010, the treated incremental load will include 51,410 tons of biochemical oxygen demand, 433,910 tons of minerals and 66,190 tons of organics.

Using minerals as an indicator of the major source of quality-related constituents, about 75-85 per cent will originate in Area 3.

Area 3 - Nonindustrial

This area covers 1,487 square miles that drains into the San Jacinto River from river mile 28 to the mouth. It includes the city of Houston.

In 1975, a treated nonindustrial return flow of 44,380 MGY will have an incremental constituent load of 6,490 tons of biochemical oxygen demand, 50,730 tons of minerals and 8,300 tons of organics. By the year 2010, the incremental constituent load will include 13,780 tons of biochemical oxygen demand, 107,790 tons of minerals and 17,640 tons of organics in 110,790 MGY return flow.

Area 3 - Industrial

Existing and/or future industrial activities will include mining, primary metal products, stone, clay and glass products, food processing, paper manufacture, organic and inorganic chemicals, and petroleum refining.

In the year 1975, treated industrial return flows are expected to total 75,450 MGY, with an incremental constituent loading of 9,560 tons of biochemical oxygen demand, 87,180 tons of minerals and 12,340 tons of organics. By the year 2010, the treated industrial return flow is expected to total 230,597 MGY, with an incremental constituent loading of 29,550 tons of biochemical oxygen demand, 262,560 tons of minerals, and 38,130 tons of organics.

TABLE S.?-1

AREA AND POPULATION DATA
SAN JACINTO RIVER BASIN AND ADJOINING AREAS

Area	River Reach (mi.)	River Miles	Area (sq. mi.)	Population 1975	Population 2010	Population Density (per sq. mi.) 1975	Population Density (per sq. mi.) 2010
1		72	931	13,200	16,400	14.18	17.62
2		94	1,856	40,800	39,700	21.98	21.39
3	0-28	28	1,487	[illegible].200	3,028,700	961.13	2036.78
4	0-28	28	251	53,800	117,900	214.34	469.72
			4,525	1,537,000	3,202,700		

Note:

Area 1 is on the East Fork of the San Jacinto River.

Area 2 is on the West Fork of the San Jacinto River.

Area 3 and Area 4 are on the San Jacinto River.

All distances are map scaled.

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TABLE SJ-2

MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS AND QUANTITY AND QUALITY OF RETURN FLOWS
SAN JACINTO RIVER BASIN AND ADJOINING AREAS

	1975					2010				
	Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)			Quantity (MGY)		Return Flow Constituents After Treatment (1) (Tons/yr)		
	Required	Returned	BOD	Mineral	Organic	Required	Returned	BOD	Mineral	Organic
Area 1										
Cleveland	399	276	40	300	50	742	485	50	430	70
Other	342	237	20	170	30	288	188	20	160	30
Total	741	513	60	480	80	1,030	673	70	600	100
Industrial	199	143	-	10	-	96	68	-	10	-
Nonindustrial	542	370	60	470	80	934	604	70	590	100
Area 2										
Conroe	1,148	781	60	450	70	1,773	1,171	90	670	110
Other	1,197	814	130	1,000	160	1,265	836	100	750	120
Total	2,345	1,595	230	1,730	280	3,038	2,007	230	1,740	280
Industrial	466	312	40	280	50	501	363	40	320	50
Nonindustrial	1,879	1,283	190	1,450	230	2,537	1,644	190	1,420	230
Area 3										
Houston	190,610	119,830	6,490	50,730	8,300	574,435	341,387	13,780	107,790	17,640
Total	190,610	119,830	16,050	137,910	20,640	574,435	341,387	43,330	370,350	55,770
Industrial	125,632	75,450	9,560	87,180	12,340	403,462	230,597	29,550	262,560	38,130
Nonindustrial	64,978	44,380	6,490	50,730	8,300	170,973	110,790	13,780	107,790	17,640
Area 4										
Baytown	31,845	21,317	190	1,480	240	77,520	51,785	450	3,500	570
Other	551	369	60	440	70	1,107	741	90	710	120
Total	32,396	21,686	3,270	42,470	4,200	78,627	52,526	7,780	61,220	10,040
Industrial	30,000	20,050	3,020	40,550	3,890	72,000	48,232	7,240	57,010	9,350
Nonindustrial	2,396	1,636	250	1,920	310	6,627	4,294	540	4,210	690
All Areas										
Total	226,092	143,624	19,610	182,590	25,200	657,130	396,593	51,410	433,910	66,190
Industrial	156,297	95,955	12,620	128,020	16,280	476,059	279,260	36,830	319,900	47,530
Nonindustrial	69,795	47,669	6,990	54,570	8,920	181,071	117,333	14,580	114,010	18,660

(1) Assumed treatment: 90% reduction of B.O.D. (Biochemical oxygen demand) and organic matter in municipal wastes and an equivalent quality in industrial return flows.
15% reduction of mineral matter.

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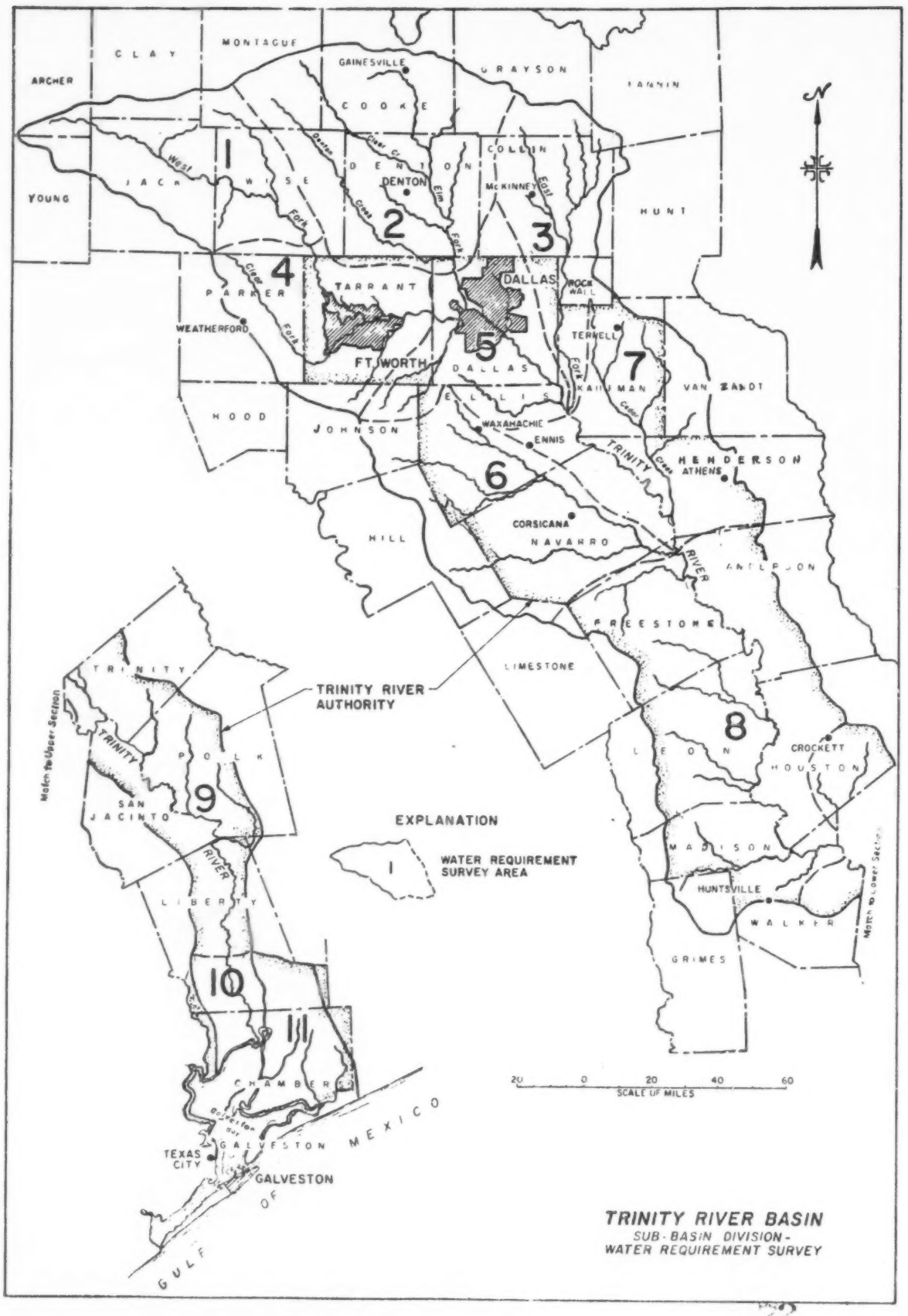
CLAY
MONTAGUE
ARCHER
GAINESVILLE
GRAYSON
FANNIN
COOKE
COLLIN
DENTON
McKINNEY
YOUNG
JACK
WISE
HUNT
PARKER
TARRANT
DALLAS
ROCKWALL
WEATHERFORD
FT. WORTH
TERRELL
KAUFMAN
VAN ZANDT
HOOD
JOHNSON
ELLIS
WAXAHACHIE
ENNIS
HENDERSON
ATHENS
CORSICANA
NAVARRO
HILL
ANDERSON
FREESTONE
LIMESTONE
TRINITY
POLK
SAN JACINTO
LIBERTY
CHAMBERS
GALVESTON
TEXAS CITY
LEON
CROCKETT
HOUSTON
MADISON
HUNTSVILLE
WALKER
GRIMES
TRINITY RIVER AUTHORITY
Main to Upper Section
Main to Lower Section
EXPLANATION
WATER REQUIREMENT SURVEY AREA
SCALE OF MILES
GULF OF MEXICO
TRINITY RIVER BASIN
SUB-BASIN DIVISION-
WATER REQUIREMENT SURVEY

TRINITY RIVER BASIN

Evaluation of the return flows and incremental waste constituent will be added at a later date.

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